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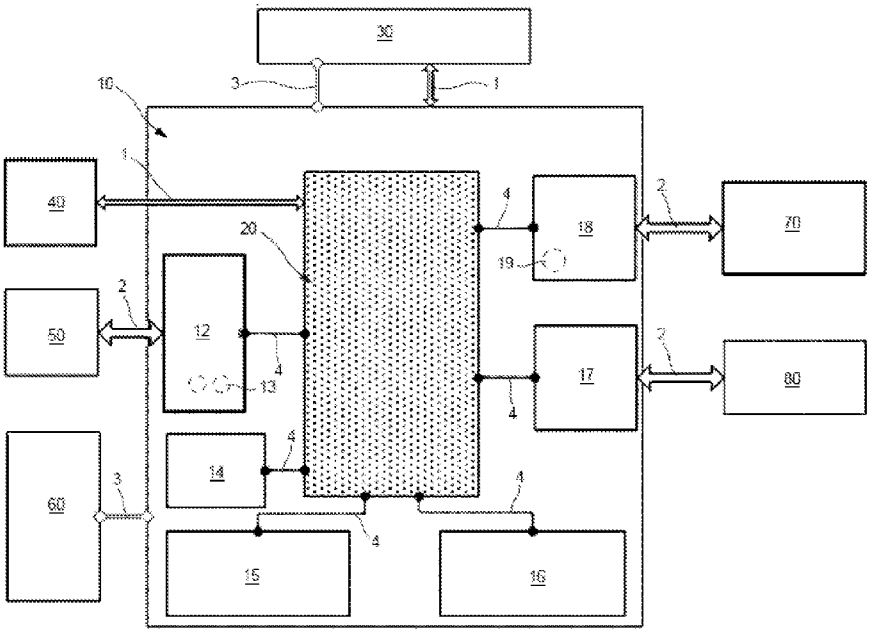

Figure – 1

(57) Abstract: The present invention relates to an electronic safety, arming and firing system for missiles comprising a central controller (20); a power conditioner (12) supplied from a power distribution unit (50) and comprising at least one storing capacitor (13) adapted to supply power to the central controller (20) in case of power cut-off; an accelerometer unit (16) adjusted to provide acceleration information to the central controller (20) designed as a microelectro-mechanical system (MEMS). The system further comprises an ignition unit (18) that is connected to trigger a low-energy foil detonator (70) through an activation signal and through which the central controller (20) controls an activation signal and a high-voltage ignition capacitor (19) adjusted to charge a voltage to the ignition unit (18) in a value range of 1600-1300 volts to activate the low-energy foil detonator (70) by means of the activation signal.

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LOW-ENERGY ELECTRONIC SAFETY, ARMING AND FIRING SYSTEM

TECHNICAL FIELD

The present invention relates to an electronic safety, arming and firing unit, particularly to a safety, arming and firing unit adjusted to perform the control and communication by means of micro circuit of the safety and arming mechanism available in the munition systems.

STATE OF THE ART

In the munition systems, mechanical, electromechanical and electronic safety and arming mechanism are used for the purpose of safety, arming and firing of the warhead units. Safety and arming mechanism is employed to prevent the activation of the main explosive charge in unwanted situations and to fire the same after its arming process. Safety and arming mechanism requires some methods for the purpose of the integration, transfer, storage and operation use of the munition. This process is performed by mechanical or electromechanical safety, arming and firing systems that distinguish the warhead from the secondary explosives. After the munition leaves safely from the related platform, the safety and arming mechanism performs necessary calculations in a logic circuit by using the distance, speed, acceleration and rotation speed parameters and verifies in the same logic circuit that the appropriate conditions are available. It arms and fires pyrotechnic elements on the munition system subsequent to these processes.

An electronic safety, arming and firing unit constitute a potential improvement for the safety and reliability of the munition. Such arming and firing systems replace sensitive explosives comprising a secondary explosive in a serial explosion chain. Said explosion chain is initiated by the exploding foil initiator (EFI). EFI is a small-sized metal folio on a plastic. EFI functions to transfer the high-voltage electric charge on the pellet with a very high speed. Metal folio is vaporized due to the ignition and accelerates the plastic fuse, such that it gains a high velocity. Fuse causes impact on the explosive chain, thereby allowing for directly initiating a shock. In the electronic safety, arming and firing unit systems, motion or rotation speed of the missile is sensed through micro-electromechanical systems (MEMS) and accordingly, the warhead is armed based according to the appropriate protocol.

Electronic safety, arming and firing systems used in the munition systems comprise components such as high-speed direct current converters with a high energy output of 3000 volts, high voltage capacitor, discharge resistor and spark gap switch. Semiconductive components are big in size due to high voltage requirement in these systems and occupies too much space.

BRIEF DESCRIPTION OF THE INVENTION

Object of the present invention is to render electronic safety, arming and firing units in a compact form for small-size munition application within the scope of low-voltage use.

In order to achieve said objects, the present invention comprises a central controller; a power conditioner having a storing capacitor bank which is fed by means of a power interface from a power distribution unit adjusted to communicate with the central controller through an in-unit electrical interface and which is also adapted to provide power with the central controller in case of power cut-off; an accelerometer and tachometer unit embodied as a micro-electromechanical system (MEMS) and adjusted to provide an acceleration and rotation speed information with the central controller by means of the in-unit electrical interface and units comprising an impact sensor that transmits impact information after the munition strikes aim.

The system further comprises an ignition unit that is connected with a power interface to trigger a low-energy folio detonator through an activation signal and through which the central controller controls an activation signal over an in-unit electrical interface and a high-voltage ignition capacitor adjusted to charge a voltage to the ignition unit in a value range of 1600-1300 volts, preferably 1400 volts to activate the low-energy folio detonator by means of the activation signal transmitted by the central controller. Low-energy folio detonator is triggered by a solid-state ignition switch after 1400 volts are fed to the high voltage ignition capacitor, thereby forming a shock and firing warhead of munition. For example, it is detected that a high voltage ignition capacitor with 1400 volts does not cause any electromagnetic damage to the in-unit electrical interface on the control boards of a miniature missile. Furthermore, it is possible to choose a small-size electronic components suitable for a miniature missile system by means of use of the low-energy folio detonator. Warheads, motor and other on-monition pyrotechnic subsystem/components used in the munition systems are kept safe in case of unwanted situations and the arming and firing function is performed through a single equipment in case of appropriate conditions. Said equipment may be packaged into smaller dimensions, wherein it has a structure that can be used on small-size munition systems. Output control of the energy

stored in the high voltage ignition capacitor for the ignition can be performed through the triggered ignition solid-state switch or N-Mos controlled thyristor.

A preferred embodiment of the present invention comprises an impact switch that is connected to the central controller through the in-unit electrical interface and that is adjusted to provide an electric signal with the central controller so as to produce an activation signal in case of an impact. Said impact switch simply produces the activation signal by way of maintaining the circuit continuity fed to the impact switch instead of detecting the impact by calculating throughout the flight by means of collecting data from the environmental sensors of the central processor. In such case, the burden on the processor is reduced, thereby making it possible to achieve a central controller with a simpler components.

In a preferred embodiment of the present invention, the impact switch comprises a solid-state switch. Said solid-state switch provides a safe component that is not affected by the dynamic structure of the system.

A preferred embodiment of the present invention is configured to define the activation signal in order to switch the open circuit into the closed circuit after the impact switch supplied by the controller unit with a proper voltage senses the impact and to transmit the supply voltage to the controller unit. Preferably, while the central processor decides to activate the low-energy folio detonator, the discrete signal is used, which is formed as differential delivered by the impact sensor.

A preferred embodiment of the present invention comprises a flight motor ignition capsule, which is associated with the central controller through the in-unit electrical interface and which is connected to a power interface in an activatable manner by being activated by an ignition signal transmitted by the central controller.

In a preferred embodiment of the present invention, the central controller is configured to check the presence of the axial acceleration value provided by the accelerometer unit before producing the activation signal. Information received from the accelerometer is also used to calculate the safe leaving distance of the central controller.

In a preferred embodiment of the present invention, the central controller is connected to the missile computer through a numerical communication interface and a discrete signal interface. Both Missile computer checks the parameters of the safety system through the discrete signal interface and it is possible to instruct the central controller through the numerical

communication interface. A preferred embodiment of the present invention is a munition comprising an electrical arming and firing system above mentioned. Preferably miniature, for example, is munition having 40 mm diameter.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 illustrates schematically the architecture with environmental units of a representative embodiment of an electrical arming and firing system used in 40 mm miniature missile system.

Figure 2 illustrates a schematic view of an electrical interface of a representative embodiment of the inventive electrical arming and firing system with the munition.

DETAILED DESCRIPTION OF THE INVENTION

In this detailed description, the subject matter of the invention is disclosed through references with examples such that it does not construe any limiting meaning, but to provide a better understanding of the invention.

Figure 1 illustrates schematically a safety, arming and firing unit (10) on a 40 mm miniature guided missile with the environmental units. Safety, arming and firing unit (10) comprises a central controller (20) with a central processor unit. Said central controller (20) is connected to internal functional elements through electrical signal transmission paths that form a plurality of in-unit electrical interface (4) on a circuit board and also to external functional elements by means of the electrical interface. A power conditioner (12) is connected to the central controller (20) through an electrical interface (4) and to a power distribution unit (50) through a power interface (2). Power distribution unit (50) is connected with an external power supply (not shown) in order to provide a supply voltage to the system. A multiple number of storing capacitors (13) are attached to the power conditioner (12) circuit. Storing capacitors (13) provide the necessary power to the safety, arming and firing unit (10) in case the power from the power distribution unit (50) is cut off. In the solid-state switch structure, an impact switch (14) adjusted to cut the current in case of impact is connected to the central controller (20) through the in-unit electrical interface (4) to transmit the electric signal. As long as the impact switch (14) is operated by the central controller (20), it is continuously supplied with a voltage of 10 volt until the impact and it delivers 0 volt until the impact moment, since it is an open circuit. The impact switch is switched into a closed circuit once the impact occurs and the central controller (20) send an ignition signal of 10 volts to an ignition unit (18), to which it is connected through an electrical interface (4). An accelerometer (16) and a tachometer (15) are

designed as MEMS elements and connected to the central controller (20) through the in-unit electrical interface (4). The central controller (20) initially collects data reporting the axial acceleration and rotation speed state of the missile provided by the flight motor, the accelerometer unit (16) and tachometer (15) to arm detonators for firing main explosive charge and process these data, thereby producing an arming signal, if the distance covered is greater than the safe distance, when the distance calculated through processing is compared to the safe distance in its memory.

A capsule ignition circuit (17) is connected to the central controller (20) through the in-unit electrical interface (4) and controlled by means of the fact that the static and/or dynamic switches controlled by the central controller (20) are switched into the open/closed position. The capsule ignition circuit (17) is connected to a flight motor igniter capsule (80) through the power interface (2). The capsule ignition circuit (17) arms and ignites the flight motor igniter capsule (80) after being supplied with a discrete signal coming through a missile computer (30) that is connected with the central controller (20) by means of a numerical communication interface (1) and a discrete signal interface (3) by processing and evaluating the data from MEMS accelerometer and tachometer by the central controller. An ignition unit (18) is connected to the central controller (20) through the in-unit electrical interface (4) and to a low-energy foil detonator (LEEFI) (70) through the power interface (2). The central controller (20) accepts the safe distance value covered and the signal of the impact switch (14) as input and transfers 1400 volts to the low-energy foil detonator (70) by means of an activation signal. Said high voltage value is sufficient to ignite the low-energy foil detonator (70). The low-energy foil detonator (70) ignited explodes the warhead (not shown) by means of the shock effect. The safety, arming and firing unit (10) prevents the power from being supplied in the high-voltage ignition unit (18) by means of keeping switches in the open/safe position until the conditions mentioned in the flowchart is fulfilled as in an above-mentioned manner. A high-voltage ignition capacitor (19) on the high-voltage ignition unit (18) rises the direct current voltage value and delivers the same to the low-energy foil detonator (70) by means of the ignition signal. The central controller (20) does not allow for controlling any one of static switch or dynamic switch of the arming condition of any high-voltage ignition capacitor (19) on its own. Electrical circuits of the high-voltage ignition capacitor (19) is designed in accordance with MIL-STD-1316E ve MIL-DTL-23659F, Appendix A.

Figure 2 illustrates schematically the connection of the safety, arming and firing unit (10) with the external units on the missile. The central controller (20) accesses the missile computer (30) over a connector (32) by means of a connection cable (31) providing a numerical communication interface (1). Furthermore, the ignition unit (18) is connected to the flight motor

(83) over a connection cable (81) providing the numerical communication interface (1) by means of an appropriate connector (82). In this way, the flight motor (83) and central controller (20) communicate with each other, thereby transferring the necessary parameters to each other. Further, the missile computer (30) transfers inputs of a platform and operator as the operation parameters to the central controller (20). In addition, a console interface (40) is connected to the central controller (20) over a numerical communication interface (1) to perform every sort of test and control processes in the safety, arming and firing unit (10). A management system (60) is connected to the central controller (20) through the discrete signal interface (3) to deliver instructions, for example the instruction for the firing cancellation, to be received from an external unit.

REFERENCE NUMBERS

1 Numerical communication interface
2 Power interface
3 Discrete signal interface
4 In-unit electrical interface
10 Safety, arming and firing unit
12 Power conditioner
13 Storing capacitor
14 Impact switch
15 Tachometer unit
16 Accelerometer unit
17 capsule ignition unit
18 Ignition unit
19 High-voltage ignition capacitor
20 Central controller
30 Missile computer
31 Connection cable
32 Connector
40 Console interface
50 Power distribution unit
60 Management system
70 Low-energy foil detonator (LEEFI)
80 Flight motor ignition capsule
81 Connection cable
82 Connector
83 Flight motor

CLAIMS

1- An Electronic safety, arming and firing system comprising a central controller (20); a power conditioner (12) supplied through a power interface (2) from a power distribution unit (50) adjusted to communicate with the central controller (20) through the in-unit electrical interface (4) and comprising at least one storing capacitor (13) adapted to supply power with the central controller (20) in case of power cut-off; an accelerometer unit (16) designed as a micro-electromechanical system (MEMS) and adjusted to provide acceleration information to the central controller (20) through the in-unit electrical interface (4), characterized in that, it comprises; an ignition unit (18) connected with the power interface (2) to trigger a low-energy folio detonator (80) by means of an activation signal and through which the central controller (20) controls an activation signal over the in-unit electrical interface (4) and also a high-voltage ignition capacitor (19) adjusted to charge a voltage to the ignition unit (18) in a value range of 1600-1300 volts, preferably 1400 volts to activate the low-energy foil detonator (70) by means of the activation signal transmitted by the central controller (20).

2- Electronic safety, arming and firing system according to Claim 1, characterized in that, it comprises; an impact switch (14) that is connected to the central controller (20) through the in-unit electrical interface (4) and that is adjusted to provide an electric signal with the central controller (20) so as to produce an activation signal in case of an impact.

3- Electronic safety, arming and firing system according to Claim 2, characterized in that, the impact switch (14) is a solid-state switch.

4- Electronic safety, arming and firing system according to Claims 2-3, characterized in that the impact switch (14) is adjusted to deliver continuously the supply voltage received from the central controller (20) to the central controller (20) as electric signals to maintain the circuit continuity and configured to define the electrical signal transmission of the central controller (20) as the activation signal.

5- Electronic safety, arming and firing system according to any one of preceding Claims, characterized in that, it comprises; a flight motor ignition capsule (80), which is associated with the central controller (20) through the in-unit electrical interface (4) and which is connected to a power interface (2) in an activatable manner by being activated by an ignition signal transmitted by the central controller (20).

6- Electronic safety, arming and firing system according any one of preceding Claims, characterized in that, the central controller (20) is configured to check the presence of the axial acceleration value provided by the accelerometer unit (16) before producing the activation signal.

7- Electronic safety, arming and firing system according to any one of preceding Claims, characterized in that, the central controller (20) comprises; a missile computer (30) through a numerical communication interface (1) and a discrete signal interface (3).

8- A missile comprising an electronic safety, arming and firing system according to any one of preceding Claims.

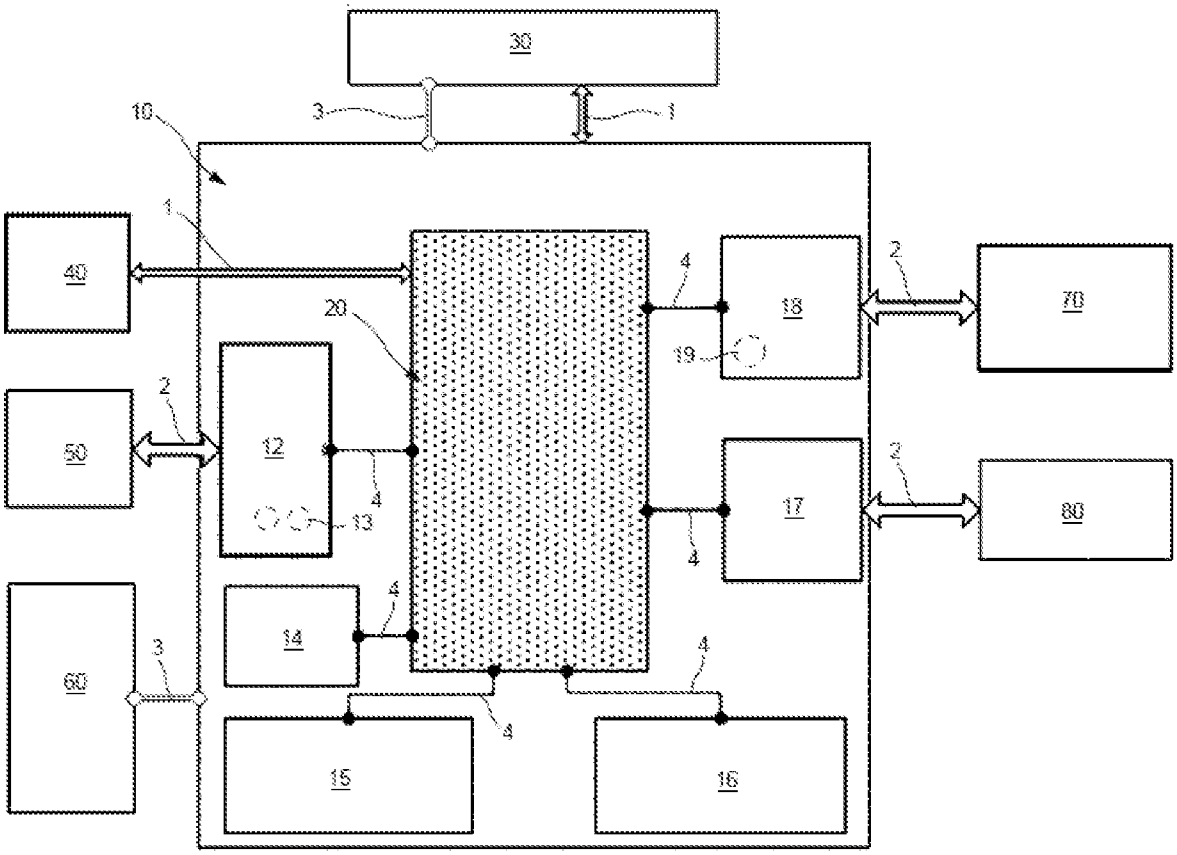

Figure – 1

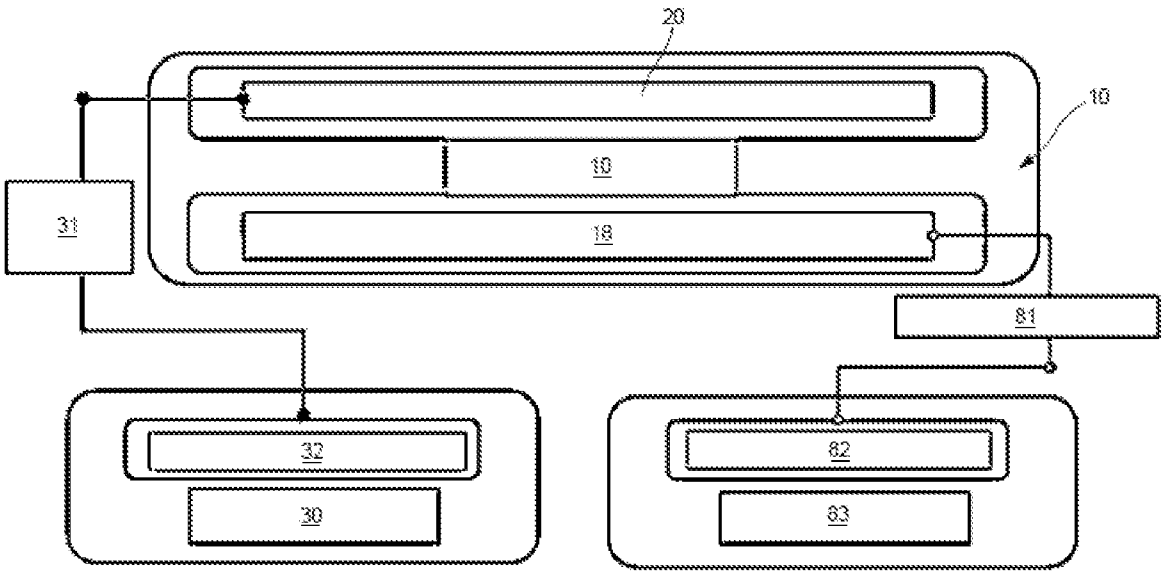

Figure – 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR2021/050544

A. CLASSIFICATION OF SUBJECT MATTER

F42C 15/18 (2006.01)i; F42C 15/40 (2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F42C 15/18; F42C 15/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1559986 A1 (LUCENT TECHNOLOGIES INC [US]) 03 August 2005 (2005-08-03) Paragraphs[10-25]; Figures[1-3]	1-8
A	US 6374739 B1 (US NAVY [US]) 23 April 2002 (2002-04-23) The whole document	1-8
A	US 2003070571 A1 (NORTHROP GRUMMAN CORP [US]) 17 April 2003 (2003-04-17) The whole document	1-8

☐ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 November 2021	**12 November 2021**

Name and mailing address of the ISA/TR	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
EP 1559986 A1	03 August 2005	KR 20050077265 A	01 August 2005
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