

Safe-and-Arm Fuzing Method For A Projectile

Field of Invention

[001] The present invention relates to a safe-and-arm fuzing method for a gun launched projectile, in particular, for a fin-stabilized projectile, which is distinct from a spin-stabilized projectile.

Background

[002] A safe-and-arm fuze is required for a munition projectile to ensure that the munition is not armed and not detonated until the projectile has been projected over a minimum distance away from the launcher and conditions are safe for arming. This munition projectile carries an explosive charge, and the safe-and-arm fuze ensures that the projectile is safe from accidental detonation on the ground during assembling, handling, storing or transporting, or safe from inadvertent detonation in the launcher. MIL-STD-1316E requires two unique environments or occurrences to be sensed or detected before it is safe to proceed with fuze arming.

[003] For gun launched projectile, the first unique environment or occurrence to detect for fuze arming is typically a setback acceleration. For fin-stabilized projectile, the spin rate is too low or too erratic for any useful sensing. To introduce a second environment sensing, a turbine, disposed at a nose tip of the projectile, has been used to sense air-flow during flight; such air-flow can also be detected by other means; however, such air flow detection means complicate use of optical sensors disposed at the nose tip of, for eg., “smart” guided projectiles.

[004] In one approach, US Patent 8,820,241, assigned to Junghans Microtec GmbH, describes a safety unit and a processor for safeguarding a detonating device. The safety unit contains a sensor unit being configured to output an enable signal when each of three directional accelerations detects a low acceleration state. The processor is set to output a control signal to arm the safety unit when the enable signal is present. A roll sensor is additionally used to identify a flight state, whilst a ground roll sensor is used to suppress output of the control signal.

[005] In another approach, US Patent 9,677,864, assigned to Orbital Research Inc, describes a self-contained ballistic apogee detection module for use in a projectile. Multiple sensors, like an accelerometer, a magnetometer and a gyroscope, provide state and orientation information to predict apogee. With apogee detection, the module outputs a signal to initiate fuze arming.

[006] Despite advances in the above approaches, it can thus be seen that there exists a need to deploy another second environment sensing by taking advantage of the unique flight characteristic or pattern of gun launched fin-stabilized projectiles.

Summary

[007] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the present invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[008] The present invention seeks to provide a safe method to ensure a gun launched projectile, in particular, a fin-stabilized mortar is in free flight before a fuze ready signal and/or arm trigger signal is/are outputted. The method would also not allow the fuze to generate a ready signal when an abnormality occurs, which would otherwise affect a trajectory to a target becoming uncertain.

[009] In one embodiment, the present invention provides a safe-and-arm fuze for a ballistic projectile. The safe-and-arm fuze comprises: a battery; a set-back switch that is operable by a setback force generated during launching of the projectile in a gun barrel; a microcontroller, a 3-axis accelerometer and an analog timer which are all connectable in parallel to receive electric power from the battery through the set-back switch; a logic AND circuit is connectable to an output of the microcontroller; and a timer-controlled switch is connectable to the analog timer; wherein after the set-back switch has been actuated, electric power is supplied to the microcontroller, to the 3-axis accelerometer and to the analog timer, and after

elapse of a predetermined time interval, the analog timer actuates the timer-controlled switch to supply electric power to the logic AND circuit, which logically operates on a positive ready signal and a complementary negative ready signal at the output of the microcontroller to issue an arm trigger signal to proceed arming of the fuze.

[0010] Preferably, the arm trigger signal further drives a sequence of mechanisms, which comprise a piston actuator mountable on a slider, a locking pin connectable to the slider at one end of the locking pin and to a rotor at an opposite end of the locking pin, so that when the rotor is released to rotate, a detonator pin becomes aligned to set off a detonator charge.

[0011] In another embodiment, the present invention provides a processing method to ensure that a munition projectile ejected from a gun barrel is in inertial flight and that conditions for a fuze located in the projectile are safe for arming. The process method comprises: fixing a 3-axis accelerometer in the projectile with an X-axis aligned in a longitudinal direction for sensing deceleration in the flight direction; connecting signals from the 3-axis accelerometer to a micro-controller; setting a loop counter (q) to operate the micro-controller in cyclic loops; computing averages of the 3-axis accelerometer signal readings within the cyclic loops and outputting the computed average readings at a predetermined initial time ($t=i$) determination and at a predetermined final time ($t=f$) determination in the X-direction (that are, a_{xi} and a_{xf}), total accelerometer magnitudes in the 3 axes (that are, a_{Ti} and a_{Tf}) and accelerometer final magnitude in the YZ lateral plane (that is, a_{yzf}); and calculating ratio R_x being a_{xf} to a_{xi} , ratio R_T being a_{Tf} to a_{Ti} and ratio R_{yz} being a_{yzf} to a_{xi} ; wherein $R_x < 1$ and $R_T < 1$ would indicate that the projectile is decelerating continuously and gradually, and that the projectile is safe, with $R_{yz} < 1$, before a ready signal is outputted to proceed with arming of the fuze.

[0012] Preferably, the above process outputs a complementary negative ready signal when $R_x < 1$, $R_T < 1$ and $R_{yz} < 1$, and computes a logical AND function on both the positive and negative ready signals to generate an arm trigger signal.

[0013] Preferably, the predetermined initial time determination is substantially 2s and the predetermined final time determination is substantially 8s from launch of the projectile. In one embodiment, the initial and final time determinations are provided by an internal clock in the micro-controller; in another embodiment, the initial and final time determinations are provided by an analog timer.

[0014] In one embodiment, moving average accelerometer readings are obtained when the micro-controller algorithm parameter (k) is set numerically at a multiple of m and the micro-controller is sampling at m Hz; in another embodiment, simple average accelerometer readings are obtained when the micro-controller algorithm parameter (k) is set numerically at m and the micro-controller is sampling at m Hz.

[0015] Preferably, the projectile is declared to be in free flight when R_x is substantially < 0.65, R_T is substantially < 0.8, R_{yz} is substantially < 0.45 and the magnitude of acceleration in the X-direction is bounded below 12 m/s^2 , after examining scenarios of the projectile are being transported.

[0016] Preferably, the above process further comprises activating a set-back switch to turn on electric power from a battery to the accelerometer, to the microcontroller and to the analog timer, wherein the set-back switch is actuated by launching of the projectile in an associated gun barrel.

Brief Description of the Drawings

[0017] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0018] FIG. 1 illustrates a block diagram of a safe-and-arm fuze employed in a fin-stabilized projectile according to an embodiment of the present invention; and

[0019] FIGs. 2A-2B illustrate time periods for processing the accelerometer readings taken during the flight trajectory after the projectile has being propelled out of a gun barrel but before reaching an apogee; FIG. 2C illustrates a process algorithm for capturing and outputting accelerometer readings at a predetermined initial time determination and at a predetermined final time determination, and determining free flight characteristics before issuing a ready signal and an arm trigger signal; and FIG. 2D illustrates a variation of the process algorithm shown in FIG. 2C.

[0020] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the present invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0021] In the following description, a 3-axis accelerometer 140 is employed in a fuze 100 of a fin-stabilized projectile 105 to detect a characteristic deceleration in the inertial or ballistic profile of the projectile, that is, after the projectile has been propelled out of a gun barrel and is in free flight without propulsion. A convention is adopted so that when an axis of the accelerometer 140 senses free-fall, the associated accelerometer reading is initialized as zero; when an axis of the accelerometer 140 is supported on a ground surface, the associated accelerometer reading is initialized a value g due to gravity. The X-axis, as seen in FIG. 1 or FIG. 2A, is taken along a longitudinal axis of the projectile 105 and detects acceleration or deceleration along the flight direction, while the Y- and Z-axes correspond to orthogonal directions to sense motion in a plane lateral to the flight direction. For eg., when the projectile 105 is supported on the ground, the Y-axis is taken to point into the ground and is initialized a value $g=9.81 \text{ m/s}^2$ while the Z-axis is directed away from the reader.

[0022] FIG. 1 shows a block diagram 101 of the safe-and-arm fuze 100 according to an embodiment of the present invention. As shown in FIG. 1, the safe-and-fuze 100 includes a power supply or a battery 110, a set-back switch 115, an analog timer 120, a microcontroller 130, a 3-axis accelerometer 140 and associated circuit board 107 and accessories, such as resistors, capacitors, inductors, and so on. The 3-axis accelerometer 140 is mounted in the projectile 105 so that the X-axis is aligned in a longitudinal axis of the projectile or direction of travel, and the Y- and Z-axes are orthogonal to the X-axis according to the above convention. The fuze 100 is activated both electronically and mechanically for higher safety consideration. For eg., to determine that the projectile 105 is in inertia flight and is not under any undesirable lateral disturbances, an algorithm 200 in the microcontroller 130 processes the accelerometer readings in the X-direction, total magnitude in the 3 axes and magnitude

in the plane lateral to the X-axis; once these three conditions (as will be described later) are satisfied, the projectile 105 is determined to be in inertial or free flight and the algorithm 200 proceeds to generate a positive ready signal 135 and a complementary negative ready signal 137 to prepare the fuze for arming. For additional safety, the analog timer 120 is used to control a switch 122 to supply power to a logic AND block 145, to which the positive ready signal 135 and the negative ready signal 137 are logically AND to output an arm trigger signal 147. Once issued, the arm trigger signal 147 initiates a mechanical chain sequence, as shown in function blocks 150 to 190. For eg., in function block 150, a single pole double throw (SPDT) relay 152 is activated. When the SPDT relay 152 is closed, a piston 153 is actuated and, in turn, a slider 154 on which the piston is mounted is displaced, as indicated in block 160. After the slider 154 is displaced, a lock pin 155 is released through a hole 158 in the slider under influence of a spring force, as indicated in block 170; as a result, a rotor 156 which was held in place by the lock pin 155 is also released and is allowed to rotate, as indicated in block 180. The rotor 156 rotates and aligns a detonator pin to activate an explosive charge train. In this manner, the ready signal 135, the complementary negative ready signal 137 and the arm trigger signal 147 are electronically generated when the projectile 105 is determined to be in free inertial flight; the arm trigger signal 147 then initiates a mechanical sequence of displacing the slider 154, releasing the lock pin 155 and then allowing the rotor 156 to align the detonator pin to set off the explosive charge train. In this way, the mechanical sequence provides a physical definitive chain of actions which is started by the electronic sequence in the algorithm 200.

[0023] FIG. 2A shows an inertial flight trajectory of a fin-stabilized projectile 105 after the projectile 105 has been propelled out of a gun barrel. Due to earth's gravity, the initial portion of the flight trajectory is parabolic until the projectile 105 reaches an apogee or apex of the parabolic trajectory; after the projectile has reached the apogee, some flight control fins or canards 109 may be deployed near a front end of the projectile to steer the projectile 105 to the intended target point.

[0024] As can be seen from FIG. 2A, the launch barrel is held at an inclined angle to the ground so that the projectile 105 can reach a desired altitude, and to reach the target at a desired speed and an attack angle. After the projectile 105 has been ejected out of the launch barrel until it reaches the apogee, the projectile experiences dynamic drag forces caused by air resistance; thus, during this inertial trajectory path (ie. without any propulsion), the

projectile 105 experiences continuous deceleration and loses speed. After transiting through the apogee, the projectile 105 descends and gains speed, and may be guided by the canards 109 to reach the target point. In the present invention, the second environment sensing relies on the characteristic or pattern of the inertial flight trajectory, ie.: (1) continuous deceleration a_x along the X-axis (ie. direction of travel); and (2) continuously decreasing magnitude of total acceleration a_T in all the 3 orthogonal axes, where:

$$a_T = \sqrt{a_x^2 + a_y^2 + a_z^2} \quad \dots \quad (\text{equation 1})$$

[0025] As will be appreciated, sensing of the accelerometer readings in the Y- and Z-axes for abnormality in flight characteristics, for eg. wobbling, or an undesirable flight turn caused by a defective canard, would not allow the fuze 100 to proceed to arming and the projectile is caused to become a dud; detecting any abnormal flight characteristic or pattern helps to reduce collateral damage. The accelerometer readings in the Y-axis and Z-axis (that is, in a plane lateral to the X-axis) is given by:

$$a_{yz} = \sqrt{a_y^2 + a_z^2} \quad \dots \quad (\text{equation 2})$$

[0026] For additional safety, continuous deceleration a_x along the X-axis and continuously decreasing magnitude of total accelerometer readings a_T must not occur during transporting (both on the ground or in an airplane), handling, drop-testing, and so on, of the projectile; this additional safety concern is to check that a ratio R_{YZ} of acceleration in a plane lateral to the X-axis is less than unity, where ratio R_{YZ} is defined below.

[0027] As seen in FIGs. 2A, the trajectory before reaching the apogee may possibly take about 10 seconds. If the first two seconds of flight is not taken into account for determining the flight characteristic (because of electric noises in the accelerometer readings), the inventors have found that tracking the projectile up to a time of substantially 8 seconds from launching is sufficient for purposes of the present invention. In one embodiment, the accelerometer readings after final f seconds (or at a final time t_f determination) after the projectile 105 has been launched are compared with the accelerometer readings taken at an initial time t_i determination; these accelerometer readings at the initial time (t_i) and final time (t_f) determinations are shown graphically in FIG. 2B. When the accelerometer readings in

the X-direction and total magnitude of accelerations in the 3 axes are all decreasing, and the ratio of accelerations in the lateral plane is less than unity, these conditions are expressed by the following ratios:

$$a_{xi}/a_{xi} = R_x < 1$$

$$a_{Ti}/a_{Ti} = R_T < 1$$

$$a_{yz}/a_{xi} = R_{yz} < 1$$

These three conditions of the second environment sensing will become clearer after the following disclosure is described.

[0028] It is possible that the flight trajectory is tracked at shorter time intervals, such as, every 1s interval; this depends on selection of the microcontroller 130 and parameter (k) setting in the algorithm 200. Parameter k depends on both the sampling rate of the microcontroller 130 and noise in the accelerometer readings.

[0029] To detect the above flight characteristics #1, the inventors have devised the process algorithm 200, shown in FIG. 2C, according to one embodiment which employs the analog timer 120. As shown in FIG. 2C, the algorithm 200 starts at step 205 when the microcontroller 130 is powered up after the setback switch 115 is actuated upon firing of the projectile 105 from the barrel of a gun or launcher. At the same time, the analog timer 120 is also simultaneously started. Upon starting, in step 210, the algorithm 200 is initialized with the parameter k=200 and a loop counter q=1 with the microcontroller sensing at 100 Hz; the parameter k is set at a numeral twice the microcontroller sampling frequency of m Hz (in this embodiment to obtain a moving average). Proceeding, in step 220, moving averages of the accelerometer readings from n=1 to n=200 in the X-direction, total readings in the 3 orthogonal axes and readings in the plane lateral to the X-axis are computed according to the following equation:

For $n \leq k$,

$$a_{mave, n} = a_{mave, n-1} \frac{n-1}{n} + a_n \frac{1}{n}$$

For $n > k$,

$$a_{mave, n} = a_{mave, n-1} \frac{k-1}{k} + a_n \frac{1}{k}$$

.... (equation 3)

For the subsequent counts of $n > 200$, the moving average of the accelerometer readings is simplified to:

$$a_{mave,n} = a_{mave,n-1} \frac{199}{200} + a_n \frac{1}{200} \quad \dots \quad (\text{equation 3a})$$

[0030] In the above moving average computation, the average in a previous time period is averaged out with readings in a current time period to obtain a moving average of the accelerometer reading. With the above computation, the accelerometer readings are not necessary to be stored in memory registers in the microcontroller but are continuously computed digitally as the accelerometer readings are sensed and the moving averages are outputted when the loop counter reaches $q=200$ and $q=800$, in respective step 230 and step 240, at these instants corresponding to the time of substantially $t=2$ and $t=8$ s after launch of the projectile. In step 250, ratios R_x , R_T and R_{yz} are computed.

[0031] Successively, in step 255, the ratios are compared to unity. If all the three ratios are less than unity, the algorithm 200 issues both the positive ready signal 135 and the complementary negative ready signal 137. The positive ready signal 135 and the negative ready signal 137 are logically AND (in step 270) to issue the arm trigger signal 147.

[0032] In one embodiment, power to the logic AND block 145 is controlled by the analog timer 120 via a timer-controlled switch 122. It is envisaged that using the analog timer 120 provides additional safety, reliability and precision than relying entirely on the internal clock in the microcontroller 130 to determine time at substantially $t=2$ s and $t=8$ s.

[0033] If all the ratios R_x , R_T and R_{yz} are < 1 , it means that the projectile 105 is decelerating continuously and gradually, is in free flight and safe for arming the fuze. If the decision in step 255 is negative (meaning any one of the three ratios is equal or greater than unity), the algorithm 200 ends and the projectile 105 is caused to become a dud.

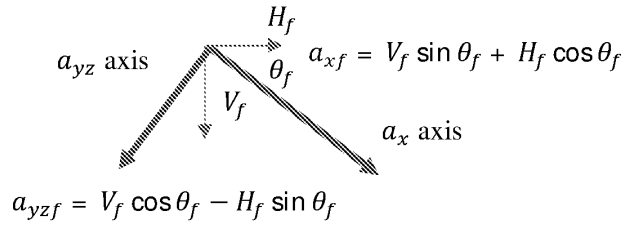
[0034] In an alternative embodiment shown in FIG. 2D, an algorithm 200a is employed where accelerometer readings are taken by relying on the internal clock in the microcontroller. The algorithm 200a is similar in operation as algorithm 200 and

correspondingly similar functional blocks are given the same technical reference numerals except for the suffix “a”; as such, no further explanation of the algorithm 200a is required.

[0035] In the above algorithms 200, 200a, multiple accelerometer readings are taken during each time period, the moving average accelerometer readings smoothen out any electrical noise signals, so that effects of noise signals in the readings are minimised. An advantage of using the algorithms 200, 200a is simple computation and it does away with use of low-pass filtering at each signal line. Even with some electrical noise in the readings, the ratios of the accelerometer readings below unity would suggest continuous deceleration of the projectile 105 in the flight direction. Even if small finite number of accelerometer readings are taken during each time period, moving average accelerometer readings obtained are still useful for the present invention. In the algorithms 200, 200a the moving average accelerometer readings effectively spread over two time periods, in a way providing moving mean values, which allow a user to ascertain a continuous deceleration pattern.

[0036] In another embodiment, it is possible that the algorithm parameter k is set to 100 when the accelerometer is sensing at 100Hz, in other words, k is set numerically to the microcontroller sampling frequency of m Hz; in this case, the accelerometer readings are averaged over one time period of 1s duration. In other words, the average accelerometer readings obtained from equation 3 with $k=100$ provide simple average values.

[0037] In the above, ratios R_x , R_T and R_{yz} suggest continuous deceleration of the projectile 105 in the flight direction before reaching the apogee. If any abnormality occurs, the fuze 100 is not allowed to proceed to arming and the projectile 105 is determined by the algorithm 200, 200a to be a dud. By just monitoring the decreasing trend of the accelerometer readings in the X-direction and total magnitude in the 3 axes, with the ratio R_{yz} being less than unity, it is still not safe enough to distinguish free flight in the air from mechanical handling on the ground or transporting of the projectile 105; any accidental handling should also not allow the fuze to proceed to arming. To introduce more stringent conditions to ensure that the projectile is in free flight, a scenario of a pitched down projectile's acceleration in the X-axis and YZ-plane during transportation is analyzed below:



[0038] θ_f is the pitch angle with respect to a horizontal ground surface. As defined earlier:

$$\frac{a_{xf}}{a_{xi}} = R_x$$

$$\frac{a_{yzf}}{a_{xi}} = R_{yz}$$

[0039] Expressing the accelerations in terms of final specific forces in the horizontal and vertical directions give:

$$V_f \sin \theta_f + H_f \cos \theta_f = R_x a_{xi}$$

$$V_f \cos \theta_f - H_f \sin \theta_f = R_{yz} a_{xi}$$

Taking squares and combining these two equations result in:

$$V_f^2 + H_f^2 = (R_x a_{xi})^2 + (R_{yz} a_{xi})^2$$

[0040] To be as stringent as possible, the left side of the above equation should be as small as possible, which occurs when the projectile is resting on a surface without any acceleration in the horizontal plane, whilst the right side of the equation should be as large as possible. The above equation is then expressed as:

$$\frac{V_f^2}{a_{x_{max}}^2} < R_x^2 + R_{yz}^2$$

Now, when transporting the projectile 105 on a support surface, the projectile experiences a specific vertical force due to gravity and an upper bound for the acceleration in the X-axis ($a_{x_{max}}$) used in the ratio $a_{xf}/a_{xi} = R_x$ is introduced so that R_x will not be replicated on the ground when the initial acceleration is very large. The upper bound of $a_{x_{max}}$ is thus given by:

12

$$a_{x_{max,lim}} = \frac{V_{f,lim}^2}{\sqrt{R_x^2 + R_{yz}^2}} = \frac{9.81^2}{\sqrt{0.65^2 + 0.45^2}} = 12.4$$

when $R_x = 0.65$ and $R_{yz} = 0.45$. Corresponding to accelerations a_x and a_{yz} , the ratio of magnitudes of total acceleration R_T is substantially 0.8. From actual test data, it is found that for $a_{x_{max}}$ of as low as 10, the value of $R_x = 0.65$ is still valid.

[0041] These values of R_x and R_{yz} have been verified to fall within trajectories obtained from actual tests data; thus, with $R_x < 0.65$, $R_{yz} < 0.45$ and $R_T < 0.8$, when $a_{x_{max}}$ is $< 12 \text{ m/s}^2$, the projectile is undoubtedly declared to be in free flight. In other words, as supported by actual test data, when the initial time determination is $t=2\text{s}$ and the final time determination is $t=8\text{s}$, the following conditions determine that the projectile is in free flight after being launched:

$$R_x < 0.65$$

$$R_T < 0.8$$

$$R_{yz} < 0.45$$

with the magnitude of a_x being bound below substantially 12 m/s^2 .

[0042] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the present invention. For example, the microcontroller can be selected to sense the accelerometer readings at a rate lower or higher than $m=100 \text{ Hz}$, and moving averages or simple averages of the accelerometer readings can then be computed according to readings that spread over multiple time periods, two time periods or one time period. In another example, the analog timer can be selected to provide 3 output time triggers, namely, an initial time, an intermediate time and a final time determination, so that the timing process in the algorithm 200, 200a is regulated entirely by the analog timer.

CLAIMS:

1. A safe-and-arm fuze for a ballistic projectile comprising:
 - a battery;
 - a set-back switch that is operable by a setback force generated during launching of the projectile in a gun barrel;
 - a microcontroller, a 3-axis accelerometer and an analog timer which are all connectable in parallel to receive electric power from the battery through the set-back switch;
 - a logic AND circuit is connectable to an output of the microcontroller; and
 - a timer-controlled switch is connectable between the analog timer and the logic AND circuit;

wherein after the set-back switch has been actuated, electric power is supplied to the microcontroller, to the 3-axis accelerometer and to the analog timer, and after elapse of a predetermined time interval, the analog timer actuates the timer-controlled switch to supply electric power to the logic AND circuit, which logically operates on a positive ready signal and a complementary negative ready signal at the output of the microcontroller to issue an arm trigger signal to proceed arming of the fuze.
2. The safe-and-arm fuze according to claim 1, wherein the arm trigger signal further drives a sequence of mechanisms, which comprise a piston actuator mountable on a slider, a locking pin connectable to the slider at one end of the locking pin and to a rotor at an opposite end of the locking pin, so that when the rotor is released to rotate, a detonator pin becomes aligned to set off a detonator charge.
3. A fuzing method to ensure that a munition projectile ejected from a gun barrel is in inertial flight and that conditions for a fuze located in the projectile are safe for arming, the method comprising:
 - fixing a 3-axis accelerometer in the projectile with an X-axis aligned in a longitudinal direction for sensing deceleration in the flight direction;
 - connecting signals from the 3-axis accelerometer to a micro-controller;
 - setting a loop counter (q) to operate the micro-controller in cyclic loops;
 - computing averages of the 3-axis accelerometer signal readings within the cyclic loops and outputting the computed average readings at a predetermined initial time ($t=i$) determination and at a predetermined final time ($t=f$) determination in the X-direction (that

are, a_{xi} and a_{xf}), total accelerometer magnitudes in the 3 axes (that are, a_{Ti} and a_{Tf}) and accelerometer final magnitude in the YZ lateral plane (that is, a_{yzf}); and

calculating ratio R_x being a_{xf} to a_{xi} , ratio R_T being a_{Tf} to a_{Ti} and ratio R_{yz} being a_{yzf} to a_{xi} ; wherein $R_x < 1$ and $R_T < 1$ would indicate that the projectile is decelerating continuously and gradually, and that the projectile is safe, with $R_{yz} < 1$, before a ready signal is outputted from the microcontroller to proceed with arming of the fuze.

4. The method according to claim 3, further outputting a complementary negative ready signal when $R_x < 1$, $R_T < 1$ and $R_{yz} < 1$.

5. The method according to claim 4, further computing a logical AND function on both the positive and negative ready signals to generate an arm trigger signal.

6. The method according to any one claims 3-5, wherein the predetermined initial time determination and the predetermined final time determination are provided by an internal clock in the micro-controller.

7. The method according to any one of claims 3-6, wherein the predetermined initial time determination is substantially 2s and the predetermined final time determination is substantially 8s from launch of the projectile.

8. The method according to any one of claims 3-5, wherein the predetermined initial time determination and the predetermined final time determination are provided by an analog timer controlling the output of the microcontroller.

9. The method according to any one of claims 3-8, wherein moving average accelerometer readings are obtained when the micro-controller algorithm parameter (k) is set numerically at a multiple of m and the micro-controller is sampling at m Hz.

10. The method according to any one of claims 3-8, wherein simple average accelerometer readings are obtained when the micro-controller algorithm parameter (k) is set numerically at m and the micro-controller is sampling at m Hz.

11. The method according to any one of claims 3-10, wherein the projectile is declared to be in free flight when R_x is substantially < 0.65 , R_T is substantially < 0.8 , R_{yz} is substantially < 0.45 and the magnitude of acceleration in the X-direction is bounded below 12 m/s^2 , after examining scenarios of the projectile being transported.

12. The method according to any one of claims 8-11, further comprises activating a set-back switch to turn on electric power from a battery to the accelerometer, to the microcontroller and to the analog timer, wherein the set-back switch is actuated by launching of the projectile in an associated gun barrel.