ELECTRONIC SYSTEM FOR DEACTIVATION OF CLOCK-ACTIVATED BOMBS WITH THE HELP OF LIQUID NITROGEN

AKBAR RAHMANINEJAD
CIVIL AVIATION ORGANISATION OF IRAN
Keywords: Electronic switch, fast fuse, charging capacitor, cryogens

Abstract

Clock activated bombs are the most used weapons by terrorists in public places like airport terminals. This paper provides my latest research for deactivating such terror weapons by a very scientific and methodical system that uses several independent methods to deactivate such bombs. These methods are divided in two major categories, electronic method and thermo-cryogenic method. Each method is subdivided to several sub-methods depending on applications i.e. the element of bomb that is recognized to be deactivated at first by neutralizing expert, this element may be a sensor due to whether moving the bomb first or any other element of bomb that is more critical or easier to access. This system is comprised of a neutralizing vessel, an electronic system that is installed on the vessel and a cylinder of liquid nitrogen which is connected to neutralizing vessel by a cryogenic tube and a fan to blow nitrogen gas out of vessel. The fan is for prevention of any asphyxiation and or condensation of oxygen in air that may lead to oxygen rich air which might lead to explosion.

1. Introduction

A clock activated bomb is a man-made system hence; it is possible to interrupt its functionality, if and only if, we know the principles that govern it. One of the best examples for such condition is electronic wars e.g. by interruption of electronic systems of the missiles, they will be diverted from the truth goals, or it is possible by explosion of two missiles with electromagnetic-bomb head near (about some kilometers distant) a ballistic nuclear missile, to deactivate the nuclear missile easily and effectively because the very precise hit of two missiles is not necessary. In this paper two major methods are mentioned which each of them can be used independently, simultaneously, or some of sub-methods to be used step by step, all depends on the conditions that define the strategy of increasing the safe margin.

2. Electronic system for deactivating bombs.

The system comprises of a fast electronic switch like a multiplexer. This multiplexer can be for example SN74153 of TTL logic with switching time of about some nanoseconds. Or any equivalent implementation, with any kind of logic devices like microprocessors or logic gates of both kinds of sequential and, or combinational logic. In the case of using this switch for deactivation the charging capacitor unit of bomb it is proposed to implement this switch with fast power semiconductors like power transistors, CMOS (complementary metal oxide semiconductor)or IGBTs (isolated gate bipolar transistor). The CMOS technology is preferred because of its faster switching time or lower ignition current in compare of IGBTs, power transistors or SCRs (silicon controlled rectifier). The second electronic device is a very fast fuse that will blow up when a very sudden high current passing through it. The third element is a power supply delivered an output with adjustable voltage and current in range of most of batteries to be used in electronic circuit of bombs, accompanied with a very precise multi meter and several wires with electronic clamps.

1.1. Deactivating Bomb by Fast Fuse

First step in this method is finding the charging capacitor of ignition circuit then the input and output of multiplexer are connected to one side of the capacitor as depicted in figure.1. The wire of negative side of capacitor should be unshielded at two points; this can be easily done by a cutter or even a knife. The circuit of deactivating system should be connected by electronic clamps as figure.1. Which a 'four' input multiplex is connected to the negative wire of charging capacitor. For the sake of simplicity only two inputs “A” and “A1” and output “B” are shown with two addressing input: 'S1', 'S2'. In this step when negative side of capacitor is identified by a voltmeter then two virtual nodes i.e. “A” and “B” are recognized and each input of multiplex is connected to one of them i.e. inputs “A” and “A1” to node “A” then the output of multiplex is connected to node “B”.

STEP 1

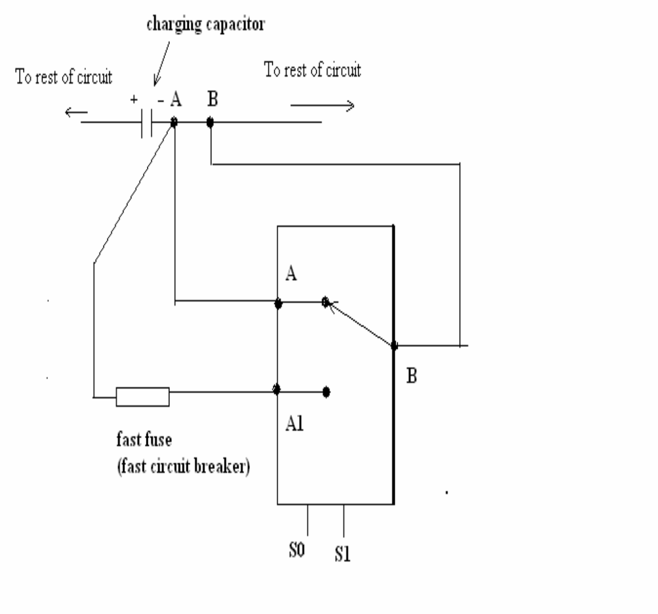


Figure.1 First Step for Connecting Bypass Switch

It is seen in Figure.2, the nodes “A” and “B” of circuit and input “A1” and output “B” is in fact one node because there is no electric element like a resistance between them. Inputs “A” and “A1” are connected to node “A” and output “B” is connected to node “B”. because there is still short circuit between Input “A” and output “B” and also there is short circuit between nodes “A” and “B” then, there is still nothing happened and in the second step by actuating address inputs 'S0S1', the input “A1” is connected to output “B” and still no disturbance happened but now a fast fuse inserted between node “A” and input “A1”. In third step, it is essential to disconnect the wire between nodes “A” and “B” of external circuit as depicted in figure.2. The nodes “A” and “B” of circuit are still connected via fast fuse input “A1” and output “B” of multiplex circuit. Because fuse has no resistance, it still behaves like a short circuit. Nodes “A” and B on wire of (preferably) negative side of discharge capacitor, is connected by path “A-A1-B-B”as the first path and the second path is directly from node “A” to node “B” by external wire that should be disconnected

STEP 2

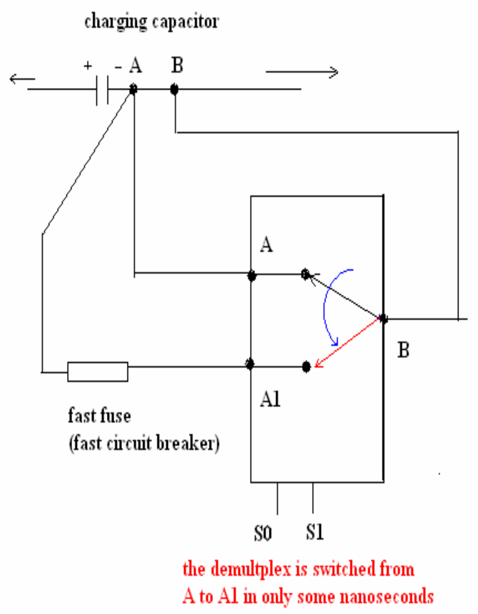


Figure.2. Switching A toA1

By a cutter .As depicted in figure.3.after cutting the wire between “A” and “B” there is only one

STEP 3

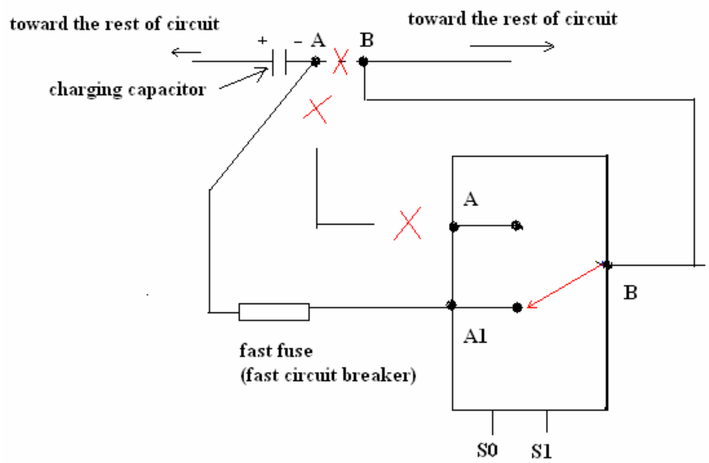


Figure.3. Disconnection of Wire

path between nodes "A" and "B" via fast fuse and input "A1" of multiplex and output "B" of multiplex. *After this step it is obvious when the electronic circuit of bomb drives the charging capacitor to send ignition pulse to detonator, the fast fuse will blow up and no electrical current or ignition pulse reaches to detonator.*

1.2. Electronic Circuit for Deactivating of Sensors and other Components

It is possible that one or some electronic sensors that are a part of the clock activated bomb, prevent moving the bomb or cause explosion of bomb in the case of any change of any factor of environmental conditions like change in temperature, etc…and sensors can be an infrared sensor or a thermal sensor or any other kinds of sensors. There is an important discipline that governs such sensors, these sensors act like normally closed or normally opened switch and with changing the environmental conditions of bomb like moving the bomb or changing the temperature of environment; the sensor changes its state. For example if it is normally closed then by changing the environmental conditions like moving the bomb, it goes to open circuit and this change in its turn actuates the ignition system of the bomb. In the case of normally opened sensor it is easy just to cut it's wires, but in short circuit case it is difficult to deactivate the sensor directly but with use of the electronic by pass circuit that replaces the sensor with a "permanent short circuit" (or with some resistance if there is some resistance). At first step two topological points "A' " and "B" of wire on one side of sensor is connected to input "A" and output "B" of multiplex. Nodes "A' "and "B" in fact is one node because there is no resistance or electronic element between them. Node "A" on other side of sensor is connected to input "A1" of multiplex. In this step no interruption to functionality is occurred, in the second step, the multiplex is switched from "A" to "A1" in just some nanoseconds and because the sensor is normally closed, there is no change in the state of the circuit and in the next step the wire between node "A' " and input "A" is disconnected and because there is still short circuit between nodes "A" and "B", no interruption occurs. in the last step the wire between "A' " and "B" is disconnected and actually the sensors is removed from the circuit and a permanent short circuit is established between nodes "A" and "B" as if the sensor is short circuit for ever and can not change it's state, hence it is possible to change the associated environmental factor for example if the sensor is a motion sensor, it is possible to move the sensor etc…

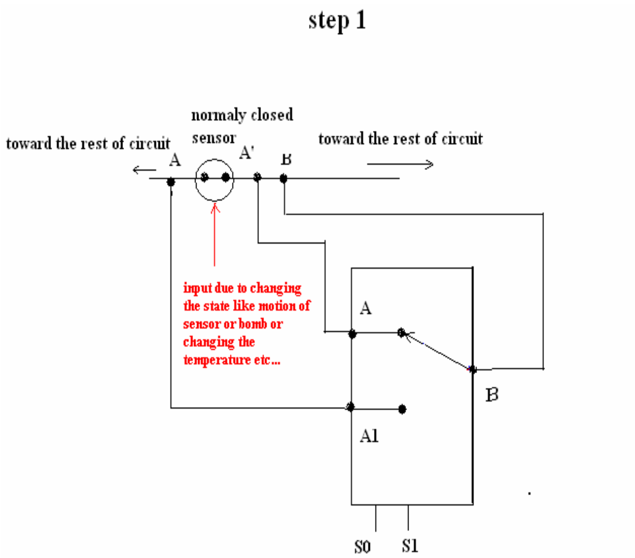


Figure.4. Connection of Bypass Circuit to Sensor

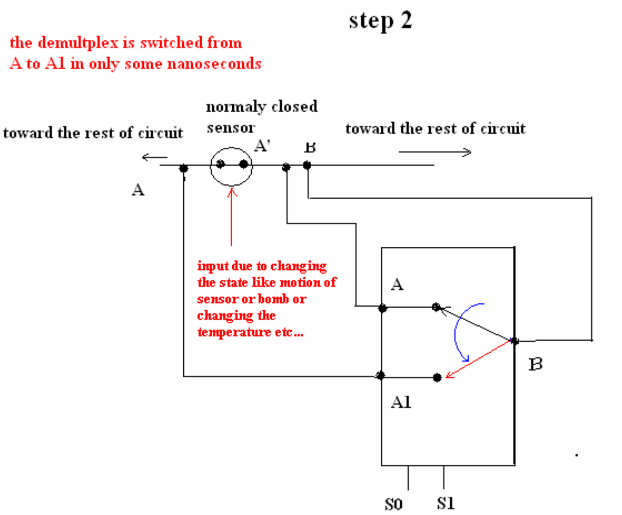


Figure.5. Switching from A to A1

It is essential to recognize that these steps can be accomplished by remote system that is depicted as attachment to this paper. This means safer and more stress-less conditions for experts to deactivate the bomb.

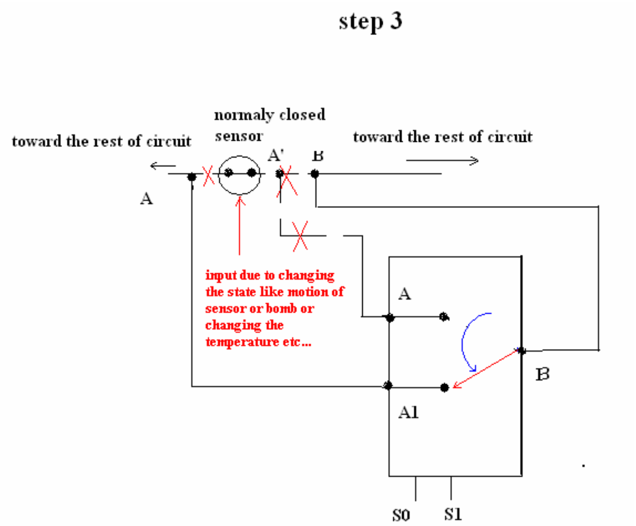


Figure.6. After Switching A to A1 in some

By this method it is possible to change any electronic element of bomb with any another desirable element or "permanent short circuit" or any constant voltage with no change in it's value.

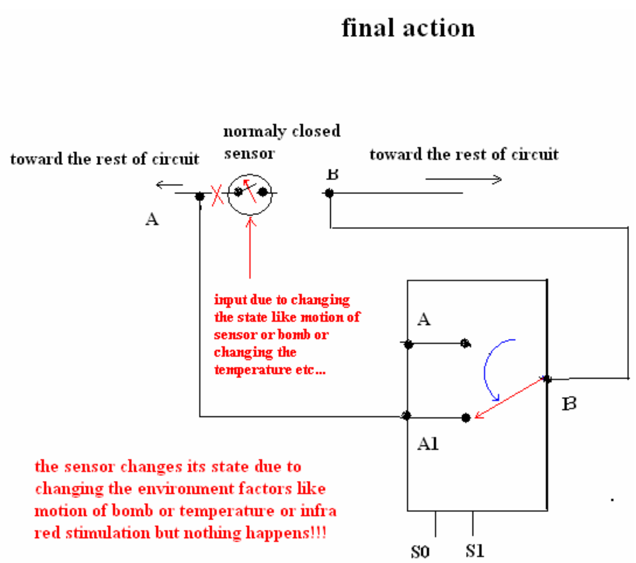


Figure.7. No Ignition Occurs When Sensor Acts

The latter case may happen when an electronic clock is used. This electronic clock supplies a specific voltage and when its counting reaches to zero then the output voltage will change. At the first step, deactivating expert measures the output voltage and then sets the very precise power supply to the specific measured value and the rest is depicted in the figures 8, 9 and10. it is obvious that when clock count-down reaches to zero, the current or voltage should be changed but power supply still supplies the specific constant values of current and voltage.

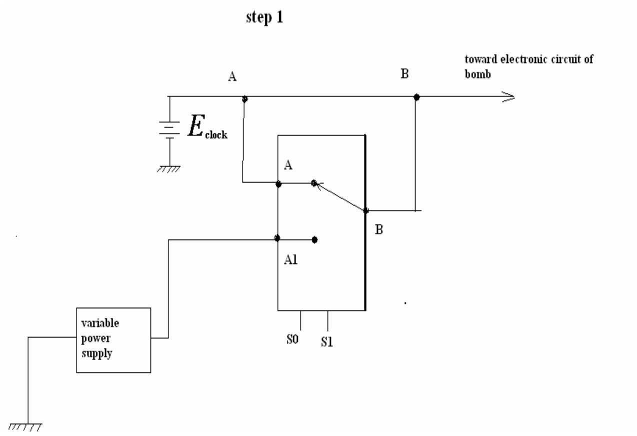


Figure.8. Schematic Diagram of Bypass Circuit

In figure 8 the connection of the multiplexes to the topological points is depicted.

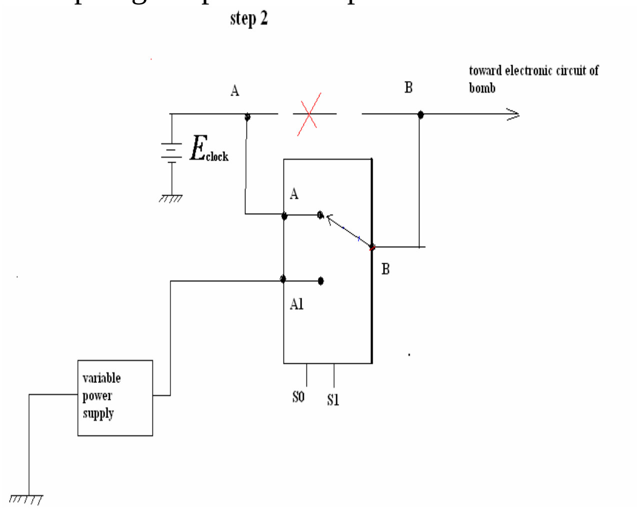


Figure.9. The Wire Cut of External Wire

As illustrated in figure.9, when the wire is cut the internal path is the main path that furnishes the electric current of battery to the electronic circuit of clock activated bomb. It is obvious the switching happens only in few nanoseconds hence the electronic circuit of bomb does not sense any change. Then in fact the power supply furnishes the current of circuit instead of the battery. Clock activated bombs need time to be exploded then all above mentioned steps can be accomplished in the delay time of the bomb.

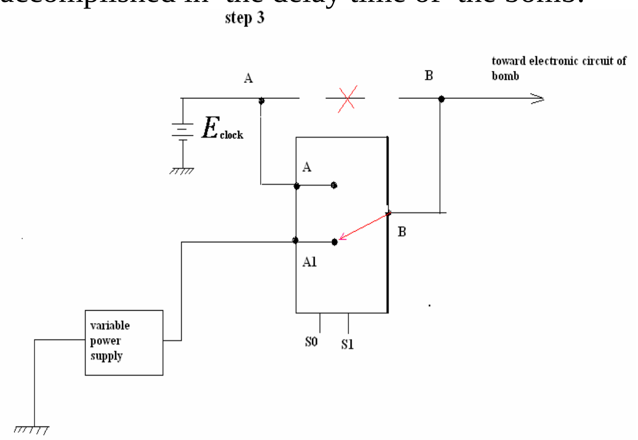


Figure.10. The output B is switched to A1

It is obvious that, this system is capable to deactivate all kinds of bombs expect those which there is no access to internal parts of them ,so in such cases there is another solution or independent method , using cryogenic freezing of clock activated bombs.

4. Deactivating by cryogenic freezing

4.1. General Explanation

Explosion is a chemical reaction that some chemicals react with oxygen in the air or oxygen contained in accompanied oxidants, but with very fast reaction rate or equivalently in very short time that leads to release of heat, light , sound and a large amount of air pressure which destroys surroundings. There are several basic factors that affect the rate of reaction or in other word the speed of reaction. This means by reducing the reaction rate it is possible to prevent the high speed reaction or in other word the explosion. These factors are temperature, pressure, concentration of chemical molecules, catalyst etc…

Among them the initial temperature is the most suitable recognized factor. All molecules in any temperature are bounded to one another but have some vibrations in the lattice about their place in the lattice with the kinetic energy of vibration as mentioned by simple famous formula:

$$E_K = \nu(\frac{1}{2}kT) = \frac{1}{2}mV^2 \qquad (1)$$

ν is the degree of freedom and k is Boltzman constant. All particles in a substance are always in motion, i.e. they possess kinetic energy. The temperature is a measure of the particles' average kinetic energy. Increasing the temperature will increase the average kinetic energy, so the frequency and energy of collisions will all increase and the chance for successful collisions will increase, so the reaction rate increases. By considering Arrhenius equation, that will discuss later, it is found that a rise of 10°C often doubles a rate of reaction and vice versa. The effect is so dramatic because the distribution of kinetic energies in a sample of particles must be considered. Although most of them may be close to average, there is a significant proportion of particles having a very high kinetic energy (and a very low kinetic energy) - called a normal distribution curve. this is the result of Arrhenius equation and very difficult to accept the result in wide range of temperatures but in very low temperatures i.e. -120 to -150 Celsius there is rarely very faint kinetic energy and all molecules bond to one another strongly, even with applying an electric current still the chance for explosion is very small and on the other hand it is most probable that the crystal or lattice of explosion

4.2. The Effect of Temperature on the Electronic Devices.

Searching the minimum operating temperature in hundreds manuals of electronic components and battery manufacturers showed there are rarely some of above mentioned component to work in less than minus 40 Celsius degree and there is not any observed component to work less than -70 Celsius degree. For improving the safe margin ,it is supposed that no electronic device or battery can operate less than or about -90 Celsius degree hence cooling down the clock activated bomb in a neutralizing vessel which is also the freezing vessel at the same time, will deactivate the battery and also the electronic components in above mentioned temperature.

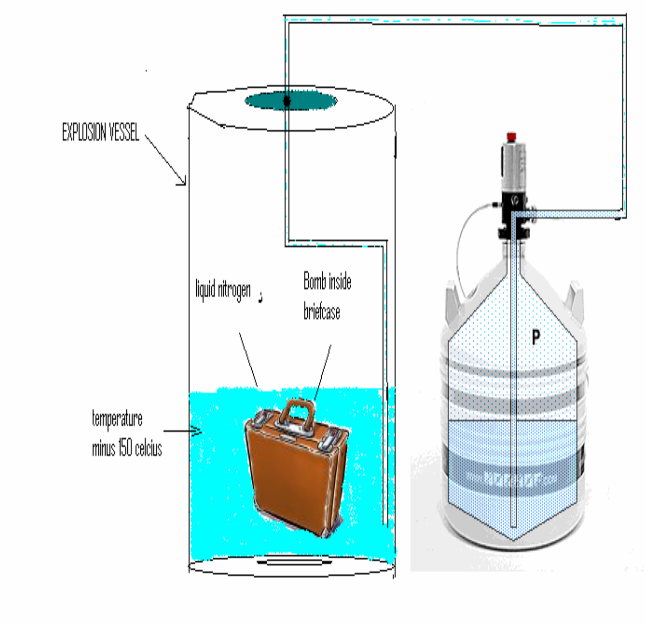


Figure.11. Deactivating Vessel

A deactivating vessel in fact is an ordinary neutralizing vessel which can tolerate a large amount of pressure or in the other words it prevents the explosion damages to outer space. by piping a liquid nitrogen cylinder to it and putting a fan on the top of it, to prevent condensation of oxygen in air and installation of deactivating circuit comprising fast switches , power supply , fast fuse , multi meter , the system is fabricated.

Temperature threshold tests by Dr. Neyer et al on hundreds of Blue Chip^{TM} Detonator of the company EG&G Optoelectronics that is for aerospace applications i.e. very low temperature operation is depicted in table.1.

Temp	Mean	Std Dev	All Fire	No-Fire
Hot (+107 C)	1196	22	1380	993
Ambient	1226	11	1343	1094
Cold (-62 C)	1300	30	1602	969

All-Fire and No-Fire levels have 95% confidence

Table.1 [1]

As it is mentioned in above table a temperature of -62C is minimum threshold temperature for such very modern electro optical detonators.

4.3. The Effect of Temperature on Detonator, Booster and Explosive

A clock activated bomb in very general scheme is comprised of electronic circuit that is ignition system, plus delay circuit and sensors, detonator, booster or primer and high energy explosive. Only and if only one of the all above mentioned parts of bomb to be deactivated then the whole bomb will be deactivated. For exploding bomb at first the electrical current is furnished by the electronic circuit, then detonator will be activated and finally boosters if included and finally main explosive will be activated. In above mentioned sequence, batteries and electronic circuit was discussed and the next parts to be discussed are detonator and finally explosive.

4.3.1. The Effect of Temperature on Detonator

Detonators are very sensitive explosive that explode faintly and produce small amount of energy but enough for activation the booster or the high energy explosive. chemical detonators shall obey the principles that govern explosive materials with the exception that, detonators are very sensitive explosives that will initiate the chemical explosion sequence. Dependence of any chemical reaction on temperature in very simple way is characterized by Arrhenius equation and activation energy. Activation energy is the minimum required energy to break the bonding between atoms of explosive material to constitute new product. The rate of reaction in very simple way is illustrated as followings:

order of reaction with respect to **A** — order of reaction with respect to **B**

$$\text{rate} = k[A]^a[B]^b \qquad (2)$$

rate in mol dm^{-3} s^{-1} — rate constant — concentrations in mol dm^{-3}

Arrhenius equation states the dependence of the rate constant to initial temperature as followings:

$$k = Ae^{-\frac{E_A}{RT}}$$

Arrhenius equation (3)

That R is the gas constant A is frequency factor or pre exponential factor E_A is activation energy and T is temperature. It is supposed that for every 10 degree centigrade change in temperature the rate of reaction will half or double .The assertion that "a 10° temperature rise doubles reaction rates" is just a rule of thumb, not a law of nature. Like most rules of thumb, "thumb times it works, and thumb times it doesn't." In fact, relying this rule to predict the effect of temperature on the rate of a chain reaction can be a catastrophic mistake hence it is essential to have so much precise experiments for calculation of the effect of temperature on detonators and high energy explosive, fortunately a lot of experiments are accomplished in related labs, using very precise formulas or codes like Livermore software program called CHEETAH code [2]. One of the very precise methods approaching the effect of temperature on detonation of explosive is: “Numerical Study on Unsteady Pathological Detonation” [3]. As pointed out by G.I. Taylor [4], the existence of a steady detonation wave depends on the ability to match the transient solution for the unsteady expansion of the detonation products to the steady boundary condition of the reaction zone, i.e. Chapman-Jouguet (C-J) plane. This matching can only take place when the flow velocity at the C-J plane is sonic relative to the shock front. This may not always be possible, e.g. imploding detonations [5]. Non-ideal effects, such as the curvature or friction can be incorporated in the conservation equations as source terms. Under these non-ideal conditions, a steady detonation solution can still be found using the so-called generalize C-J criterion [6]. The detonation solution is obtained when the competing effects of heat release, flow divergence (i.e. curvature) and friction lead to a vanishing effective heat release rate at the sonic plane. The result of above mentioned discussion leads to the two stages source term can readily be incorporated in a numerical simulation of the transient development of a detonation as: [6]

$A \rightarrow B$ (Exothermic)

$B \rightarrow C$ (Endothermic) with:

$\lambda_1 = 1 - x_A$ And $\lambda_2 = x_c$

$$\frac{d\lambda_1}{dt} = k_1(1-\lambda_1)\exp\left(\frac{-E_{a1}}{RT}\right) \qquad (4)$$

$$\frac{d\lambda_2}{dt} = k_2(\lambda_1-\lambda_2)\exp\left(\frac{-E_{a2}}{RT}\right) \qquad (5)$$

In above equations, we just deal with the effect of T, temperature in the exponents which still shows good dependence of reaction rate in both stages to the initial temperature, and other terms are not function of temperature which is a good proof for cryogenic deactivation of chemical explosive detonators.

4.3.2. The Effect of Temperature on explosives

High energy explosives are the last step or the most important step explosion sequence of bomb. One of the very profound models that is based on the modeling of double shock initiation especially applicable to TATB (Triamino trinitrobenzene) based explosives. The presented semi empirical macro kinetics detonation model was developed by Yu.Aminov, N.S. Es’Kov, and Yu.R.Nikitenko in Russian Federal Nuclear Center-VNITF, Snezhinsk, Russia [7]. There is a lot of semi empirical detonation macro kinetics models for condensed heterogeneous explosives (i.e. the most important case relating to clock activated bombs) based on “hot spots” concept. Most of them are in a good agreement with the experimental results of single -shock initiation. However, often the initiation is a result of the action of several sequential shock and rarefaction waves. Simulation of such scenarios is more serious test for detonation macro-kinetics models which presents a two-stage semi empirical kinetic model that describes basic features of the detonation development in the heterogeneous explosives. The proposed model contains the following kinetic equations:[7]

$$\frac{d\xi}{dt} = \begin{cases} -W \cdot \dfrac{\rho_{HE}}{\rho_K^{1/3} \cdot \rho_{RP}^{2/3}} \cdot \left(\dfrac{1-\xi}{\theta^*}\right)^{2/3} \cdot \exp\left(-E_a / 3E_T^*\right) \cdot U(\sigma), & \dfrac{\theta^* \cdot \xi}{\rho_{HE}} > \dfrac{1-\xi}{\rho_{RP}}; \\ -W \cdot \left(\dfrac{\rho_{HE}}{\rho_K}\right)^{1/3} \cdot \xi^{2/3} \cdot \exp\left(-E_a / 3E_T^*\right) \cdot U(\sigma), & \dfrac{\theta^* \cdot \xi}{\rho_{HE}} \le \dfrac{1-\xi}{\rho_{RP}}. \end{cases} \qquad (6)$$

These equations exhibit two stages, the first stage of model describes the ignition of hot spots, and the second one describes the surface combustion after merging of hot spots. As in the case of detonation analysis, we again only deal with temperature contained term i.e. E_T^* which is related to temperature according equation (1) in this paper. The presence of thermal energy E_T^* in equation (1) allows taking into account the dependence of high energy explosive sensitivity on its initial density and temperature. If the initial density decreases (or the temperature increases) the energy E_T^* increases what results in to the growth of the reaction rate and vice versa. *Again the important factor is the location of energy* E_T^* *in the dominator of the exponents which has the same effect almost as predicted by Arrhenius equation and again a good confirmation for cryogenic deactivation of high energy explosives.*

5. Cryogenic Heat Removal Regimes

Thermo dynamical design of freezing the whole package of a clock activated bomb inside the vessel can be designed by recognition several conditions i.e. various maximum heat load or various sizes and masses of the bomb package including explosives, electronic circuits and the cover of the bomb. Design is based on factors like heat transfer coefficient and specific heat capacity of the material in the pack and factors like latent heat of vaporization of LN2 etc etc….

The main goal is not minimizing consumed liquid nitrogen but minimizing the time of cooling down and freezing the total pack of bomb that is constituted of many materials with their own thermo dynamical specifications. From one side the urgency of the limited delay time for deactivation and from another side there is the problem of the rate of cooling down because, very fast cooling with liquid nitrogen might cause an explosion due to negative gradient of heat flow from heat load i.e. the bomb pack, but <u>this is not the destructive explosion of the bomb and is so much weaker and could be confined in neutralization vessel.</u> The only problem might arise from the probability to have the main explosion of the bomb during cooling down. Searching of hundreds of articles during several years showed that no cryogenic (freezing explosives to cryogenic temperature) lab experiment has been accomplished by creditable searching centers that are active in the field of explosion or at least such experiments do not have been published. But there are lots of experiments on heating or cooking off the explosives to find flash point or self ignition of explosives. The problem can be solved by reverse reasoning that the probable explosion of explosives during the cooling down to cryogenic temperature is due to negative gradient of heat flow from explosive to outer space. With very good safe margin if the most important kinds of explosives to be cooked off to about 200 of degree over ambient temperature and do not self exploded then it is possible to cool down the same explosive to about -200 degrees expecting no self-ignition during the process i.e. the negative gradient of heat from explosive will not cause the main explosion because during the cryogenic process the kinetic energy of molecules will decrease significantly. The second important factor during the heat removal from explosives is the rate of heat removal that by comparing the experimented rate of heating of the explosive, it is possible to find the allowed rate of cooling. P.J.Cheese et al tested the maximum heating temperature and the rate of heating of many important explosives and published. Tests are accomplished on many important explosives in electrically heated tube in two main conditions with good isolation of tube which is referred by “ lag” expression and in normal condition. [8]

Explosive	Composition
RT 60/40Type A	RDX 60%, TNT 40%, + 1% Wax
EDC1	HMX 70%, RDX 4%, TNT 25%, Wax 1%
PE4	RDX 88%, grease 12%
CPX 200	RDX 60%, 20% Aluminium, 10% binder, 10% K10 liquid
Rowanex 1001	HMX 88%, HTPB 12%
Rowanex 1301	RDX 20%, AP 44.5%, Aluminium 25%, HTPB 10.5%
Rowanex 1400	RDX 66%, Aluminium 22%, HTPB 12%
Rowanex 2000	HMX 92%, HTPB 8%

Table.2. Experimented Explosives [8]

The resultant data is depicted in the following figures.

Explosive	With lagging		Without lagging	
	Time to reaction	Surface temp.	Time to reaction	Surface temp.
RT 60/40Type A	42m	235°C	44m	237°C
EDC1	45m	242°C	47m	246°C
PE4	41m	220°C	39m	212°C
CPX 200	-	-	43m	228°C
Rowanex 1001	45m	245°C	-	-
Rowanex 1301	50m	264°C	-	-
Rowanex 1400	49m	251°C	-	-
Rowanex 2000	46m	245°C	-	-

Table.3. Heating Explosives by Rate of 5 Celsius degree per minute. [8]

In table.3 two important factors is recognized, at first the explosives all are heated to about to about 250 Celsius degree with no self explosion and it is concluded when explosives to be cooled down to about -150 Celsius degree, no self explosion will happen and the second important factor is the rate of cooling down that is too slow that can not cause reaction in less than about 45 minutes. The first row of table.3 shows the rate of 35 degree Celsius per minute in total heating time of 7.2 minutes, reaching to maximum temperature of 262°C. Hence we can conclude it is possible to have such a rate of cooling with no self explosion. It is obvious that the complete cryogenic cooling of explosive requires very expensive and complete labs and a crew of chemist having a wide range of explosive from very faint detonators to intensive high explosive and precise sealing and measuring equipment, etc… the second important factor is the rate of cooling down that may cause self explosion during the cooking off the explosives and applying these factors during the cooling down of explosives. in the following figures, rates of cooking of for TNT based and plastic based explosives respectively is depicted.

Explosive	With lagging			Without lagging		
	Heating rate	Time to reaction	Surface temp.	Heating rate	Time to reaction	Surface temp.
RT 60/40Type A	35°C/m	7.2m	262°C	5°C/min	44m	237°C
EDC1	<5°C/m	44m	240°C	<5°C/m	47m	246°C
PE4	4°C/m	54m	236°C	<2°C/m	106m	205°C
CPX 200	-	-	-	<2°C/m	104m	208°C
Rowanex 1001	<3.3°C/h	44.9h	189°C	-	-	-
Rowanex 1301	<3.3°C/h	45.1h	180°C	-	-	-
Rowanex 1400	<3.3°C/h	43.7h	160°C	-	-	-
Rowanex 2000	<3.3°C/h	47.7h	179°C	-	-	-

Table.3. Fast and Slow Heating [8]

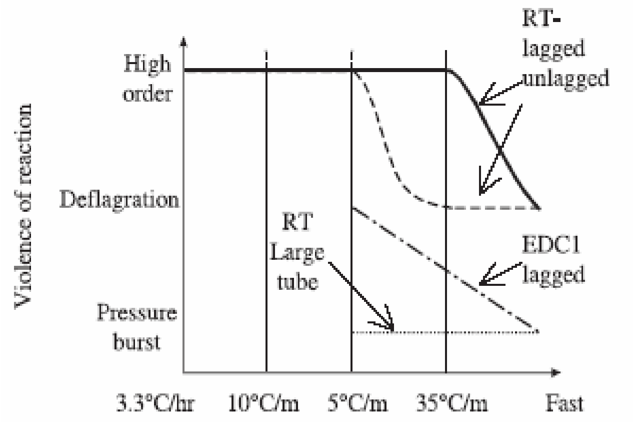


Figure.12. Violence of Reaction for TNT based Melt Cast Explosives. [8]

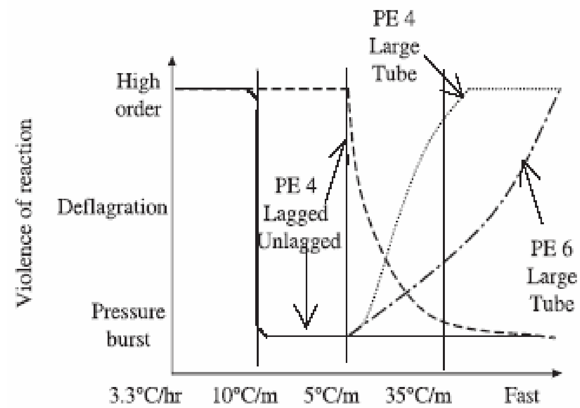


Figure.13. Violence of Reaction for Plastic Explosives[8]

As it is depicted the violence of reaction for PE6 and PE4 are increased during the cooking off process but for cooling down process, it is necessary to do the experiment in a very expensive lab and sponsored by a research center having enough and complete resources.

6. Conclusion

In this paper a number of methods and ideas covering electrical, chemical and mechanical engineering fields with exact practical methods for implementation were provided to reduce the danger of bombs which are terrorist used weapons in public places like airports. Cryogenic method is also applicable for deactivating of anti personnel land mines because of freezing the explosive of land mine and freezing firing pin and mechanical moving parts of mine which will stick firmly to their places and can not be fired by pressure during the freezing, giving enough time to be brought out of ground and moved to a safe place.

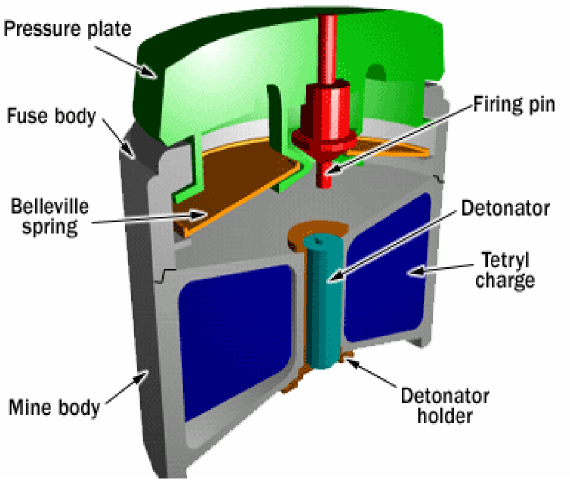


Figure.14. Profile of M14 Land Mine [9]

The paper is accompanied by electronic diagram to activate the valve of LN2 cylinder and/or S0S1 remotely to reduce any unpredicted problems. This paper contains so many details which are out of scope and also patience of one paper. Cryogenic cooling down experiments that were accomplished by the author comprised of cooling down of a small amount of some detonators and some ordinary explosives by a cryogenic spray during various times of cooling and in all cases the tested explosive was deactivated and because of lack of space in this paper, and also lack of very precise measuring and sealing equipment, this section is omitted but the result of experiments approved the cryogenic deactivation of explosives phenomenon.

References

[1] Neyer, Barry T. A Low Cost, Reliable, Hermetically Sealed, Chip Slapper Detonator Suitable for Various Aerospace Applications Proceedings of 35th Joint Propulsion Conference, Los Angeles, CA, June 1999 *Applications*

[2] Laurence Fried, Improved Detonation with Cheetah, Livermore, USA.

[3] Taylor G.I, Numerical Study on Unsteady Pathological Detonation.

[4] Ficket W, Davis ,W.C, Detonation University Of California Press, 1979.

[5] Guenoche.H, et al, Influence of Heat Release Function on the Detonation States.

[6] Dionne J.P, et al, Numerical study of Unsteady Pathological Detonation, McGill University, Montreal, Canada.

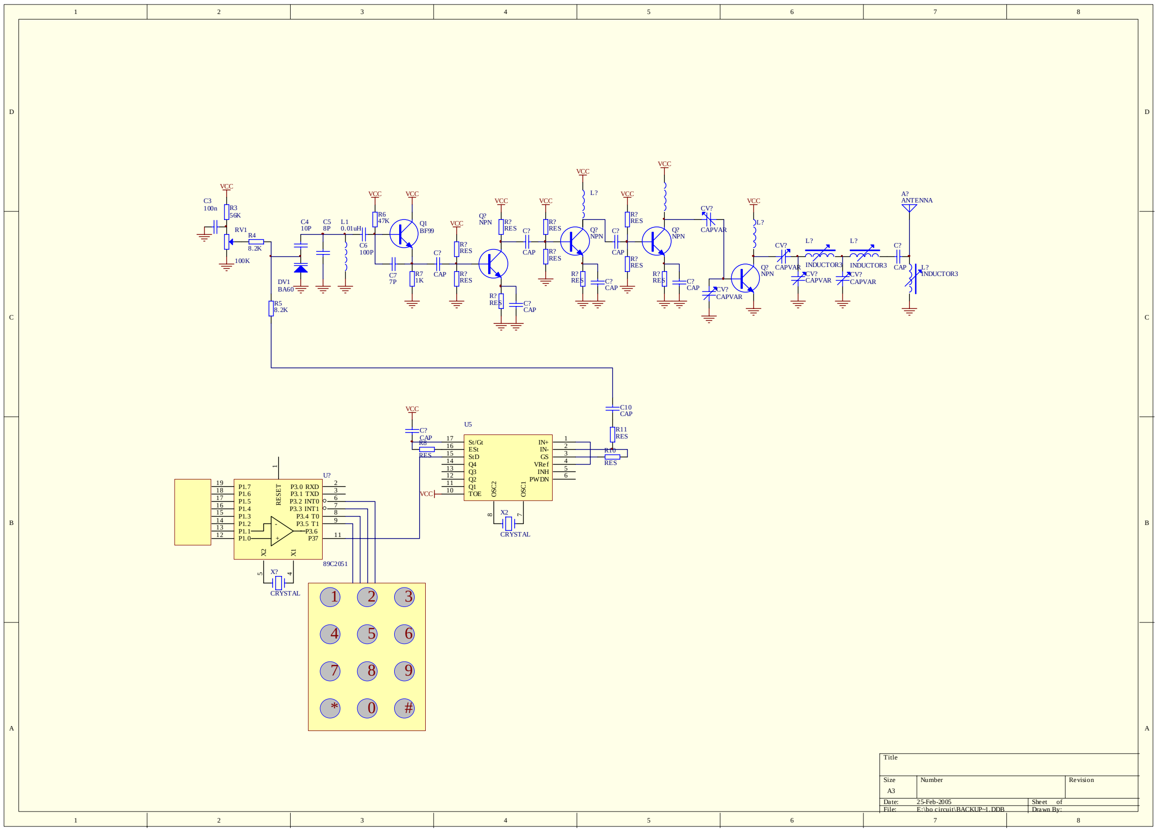
[7] Aminov, YU.A, et al, Modeling of Double Shock Initiation TATB-Based Explosives.

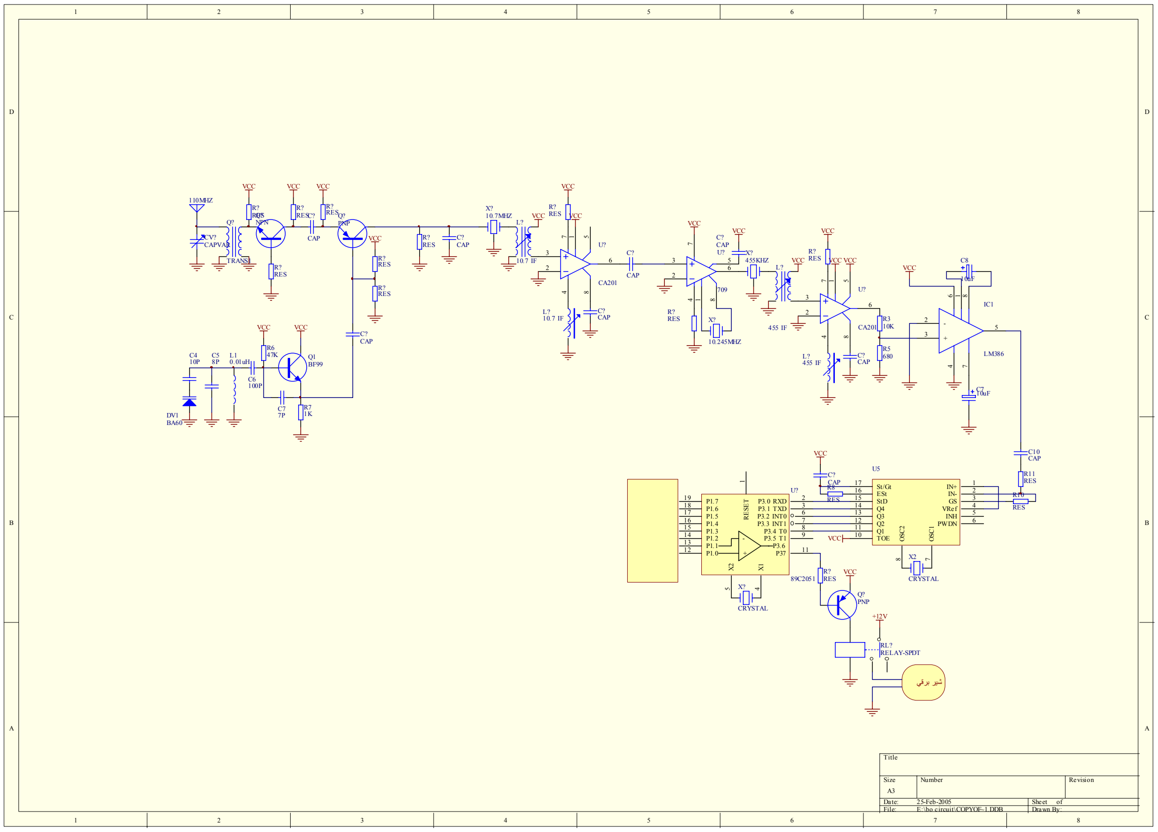
[8] P.J.Cheese, Cook off Tests on Secondary Explosives, DERA Fort Halstead, Sevenoaks Kent, YN14 7BP, United Kingdom.

[9] Bonsor Kevin, How Landmines Work

[10] Adibi, A, Electronic Circuits, Sanati Amirkabir University, Teheran, Iran.

[11] Millman.J, Microelectronics, McGraw-Hill 1979.


VCC
BF99
NPN
ANTENNA
INDUCTOR3
CAPVAR
89C2051
CRYSTAL
U5
1 2 3
4 5 6
7 8 9
* 0 #
Title
Size
A3
Number
Revision
Date: 25-Feb-2005
Sheet of
Drawn By:


110MHZ
CAPVAR
TRANS1
NPN
PNP
RES
CAP
VCC
X?
10.7MHZ
10.7 IF
CA201
455KHZ
10.245MHZ
455 IF
709
IC1
LM386
10uF
C4
10P
C5
8P
L1
0.01uH
C6
100P
R6
47K
Q1
BF99
C7
7P
R7
1K
DV1
BA60
R3
10K
R5
680
C10
R11
U5
St/Gt
ESt
StD
Q4
Q3
Q2
Q1
TOE
IN+
IN-
GS
VRef
INH
PWDN
OSC2
OSC1
X2
CRYSTAL
P1.7
P1.6
P1.5
P1.4
P1.3
P1.2
P1.1
P1.0
RESET
P3.0 RXD
P3.1 TXD
P3.2 INT0
P3.3 INT1
P3.4 T0
P3.5 T1
P3.6
P37
X1
89C2051
+12V
RL?
RELAY-SPDT
شير برقي
Title
Size
A3
Number
Revision
Date:
25-Feb-2005
Sheet of
File:
E:\bo circuit\COPYOF~1.DDB
Drawn By: