Developing deployer for Sugar Rocket using Spring method

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Present to

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Abstract

In order to deploy components from a rocket we need a deployer force to push components out. The most popular method is to use a set timer Propellant Grain. But a heat and explosive impact from the Propellant Grain method can also cause damage to other components such as payload parachutes and the rocket body itself. On the other way using a spring as deployer force. Unlike a Propellant Grain spring doesn't have heat and explosive force, But in the nature of spring it tries to be back at its equilibrium point so it creates a resistance force which is deployer force when we pack everything inside a rocket, therefore, we have a gate lock. , And is be able to lock and release automatically by itself, in three condition mercury switch, acceleration and timer so it can release at the highest altitude or altitude that we want. This device is designed to be able to use repeatedly in a sugar rocket or low-altitude rocket.

Introduction

After using Grain deployment method we suffer damage that causes by Propellant Grain deployment method which is heat and explosive impact. We saw that other people also have a similar problem. That is an inspiration for us to create and develop a deployment system that wouldn't cause it.

At first, we have several solutions for heat and explosive impact problems such as rubber shot method, Hydraulic or gas pressure method, spring and lock method, and horizon deployment method. Under a requirement the device fit in rocket

body which diameter is 80mm or 8cm and make from paper . We saw that a spring and gate lock method has the highest ratio between occasion deploying payload and recovery system , mass , size And doesn't cause any damage to payload, recovery system, and rocket itself.

Criteria in occasion deploying can reject payload and recovery system, able to reject at the highest altitude or altitude that we want, Material can be working under these conditions high temperature from Ignition and throat, high acceleration, high pressure and though a Vibration, Able to be reused, Easy to set up inside small diameter rocket. For don't cause damage determine by a characteristic of the material as is it flammable a stage of it. Mass and length affect to design rocket stability and also the altitude of rocket.

Sugar rocket is a solid fuse rocket type fuse are made by any type of sugar and have Potassium nitrate as oxidizer in 7:13 ratio. Preparation to make sugar rocket is simple so it use for studying model

PLA or Polylactic acid, is a thermoplastic polyester. Monomer derived from renewable, organic sources such as corn starch or sugar cane. Properties of PLA is soluble in solvents including dioxane, hot benzene, and tetrahydrofuran. The physical and mechanical properties differ according to the exact type of polymer, ranging from an amorphous glassy polymer to a semi or highly crystalline polymer with a glass transition of 60–65 °C, a melting temperature 130-180 °C, and a tensile modulus of 2.7–16 GPa. .Heat resistant PLA can withstand temperatures of 110 °C, and the melting temperature can be increased by 40–50 °C and the heat deflection temperature can be increased from around 60 °C to as much as 190 °C by physically blending the polymer with PDLA (poly-D-lactide) and density is1.24 g/cm³.

The equation for calculating spring

(1)

(2)

Where

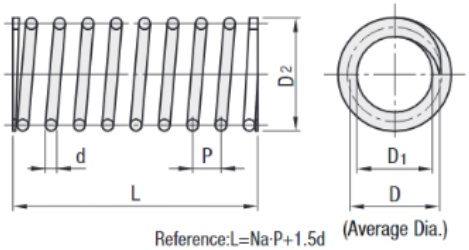
(4)

(6)

height in mm

(3)

(5)



figure(1)

Sensor and elctronic handware

- GY-91

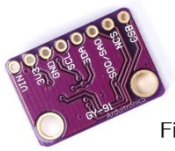


Figure (2)

s Mass in kg

GY91 is combire MPU9250 and BMP280 module which have Three-axis gyroscope + triaxial accelerometer + triaxial magnetic field + pressure Operation Voltage at 3.0 - 5.0 Volts figure 2

- MG90s

Figure (3)

MG90S micro servo motor, Metal Gear , Full Ball Bearing , Less Noise . Have a Stall Torque of 2.0-2.5kg/cm Operation Voltage at 4.8 - 6.0 Volts figure 3

- Micro SD adapter

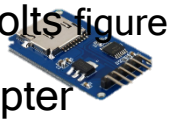


Figure (4)

The module is a Micro SD card reader/ writer module, through the file system and the SPI interface driver. Supports Micro SD cards, Micro SDHC card. voltage inside regulator circuit is 3.3 Volts Operation Voltage at 4.5-5.5 Volts figure 4

- Micro SD card

Figure (5)

Collecting data form sensor in system figure 5

- xh2.54 connector 2 pin and 7 pin

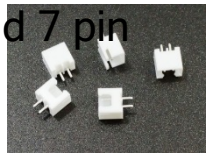


Figure (6)

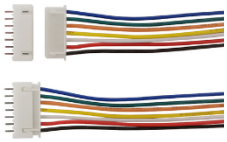


Figure (7)

Connecting power to each component figure 6,7

- lithium polymer 450 mAh 11.Wh

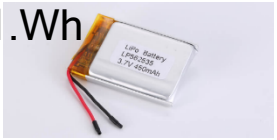


Figure (8)

A power source in a system output Voltage 3.7Volts Capacity 450mAh Operating voltage range 2.75 - 4.2 Volts figure 8

- Step down

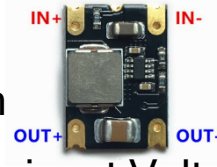
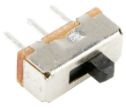


Figure (9)

step-down an input Voltage to operation module Voltage. Operating step 15V 12V 9V 7.4V to 5V 4A figure 9



- Slide Switch

Figure (10)

Simple SPDTslide switch use foe on/off a system figrue 10

- PCB

Figure (11)

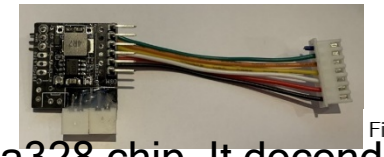


Figure (12)

In this PCB it include Atmega328 chip. It decending size and wight and there is no unessential wide figure 11, 12

- Mercury switch

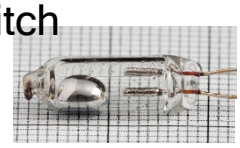


Figure (13)

Place it horizontally the mercury in the switch keep the circuit connected, and when you tilt it the connection will lose. Figure 13

Macanic material

- Rubber figure 14 15

Figure (14)

- Balsa wood figure

- M3 screw figure 16 figure 17

Figure (16)

- Cable Tie

Figure (15)

- Tissue core figure 18 figure 19

Figure (18)

- Aluminum tape

Figure (19)

- PLA plastic figure 20

Figure (20)

Methodology

- System Flowchart figure 21

- Circuit board and PCB diagram figure 22-23

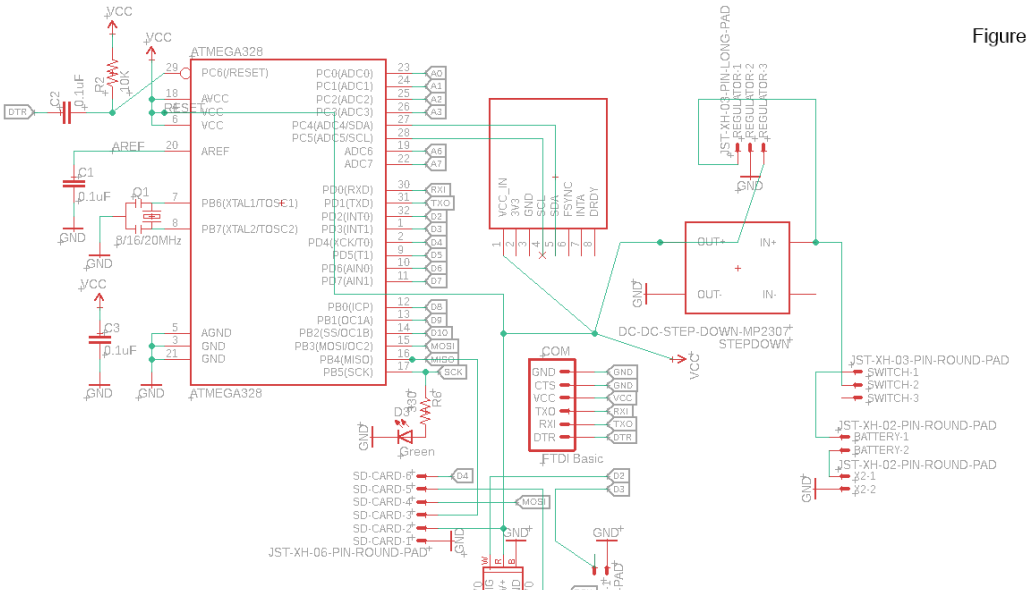


Figure (21)

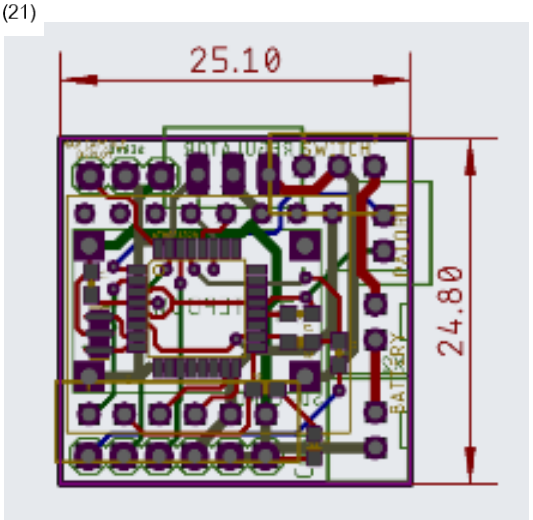


Figure (23)

Figure (22)

- Pin Design figure 24

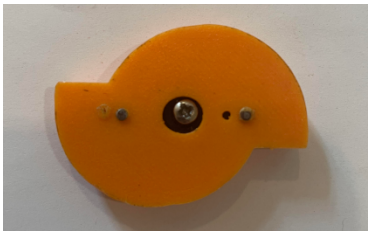


Figure (24)

- Latch Design figure 25-27

Figure (25)

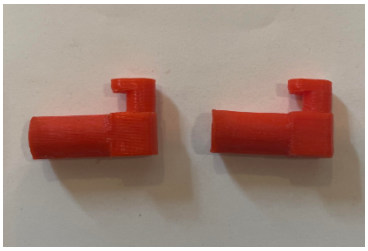


Figure (26)

Figure (27)

- Box Design figure 28-29

Figure (28)

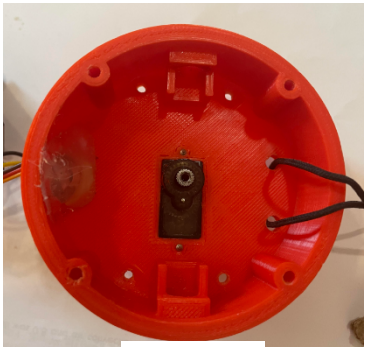
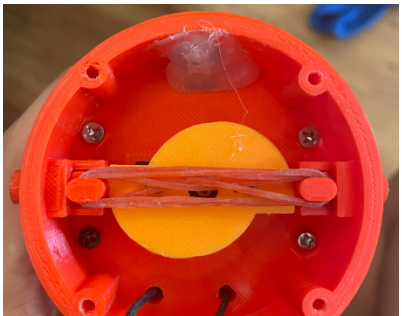
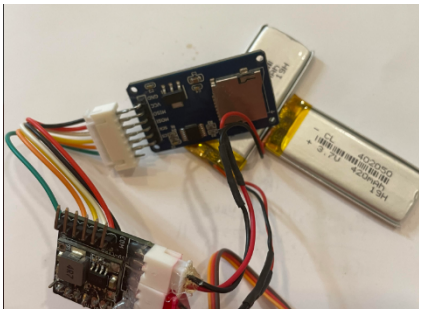


Figure (29)

Figure (30)





- Gate and lock

The Lock are consist by Latch and Rubber. Latch are In cylinder shape made by PLA with 3M screw as a core,Rubber are use for pull these two latch together figure 31-32 Servo ,PCB ,sensor And pin figure figure 33-34 are include in The Gate. The gate have duty to determine altitude of releasing. When assemble The Gate are separate into parts . A PCB and sensor are place inside a PLA nose cone with SD Card module and battery there also have bubble wrap to prevent wire disconnected from rocket vibration as figure figure 30 A servo, pin and The lock are within a PLA box below a nose cone as figure figure 35 A box have four 3M hole for assemble with nose cone and four for partition

- Spring

A mass of a rejection object is 375 g and displacement

s
p
a
c
e

both top and bottom piston are Balsa which diameter is 78mm in a body made of tissue core which has 100mm in length. A bottom balsa and tie with spring as figure 36 bottom of spring is tire with balsa with Aluminum tape and will lock by 3M screw with a rocket body

1
2
0

- Working mechanism

m
m

After assemble all components rubber will pull a latch together as figure figure 32 this stage is Gate release position. Turn on a switch a servo rotate 90 degree a pin will be in Gate lock position figure 31. Condition to change form Gate lock position into Gate release position acceleration sensor in Gy91 have to detect acceleration over 2.0 G-force over 200ms then timer start after 8 second noise . If it is 1of3 condition a pin

w
e
i
g
h
t

o
m

position will change into release position , The condition are detect acceleration under 0.2 G-force for 300ms or mercury switch circuit compete over 400ms or timer go over 14 second. Meanwhile Sd card with collect all data since switch on. And only way to change from release position to lock position is re-open a switch.

Result

At home we simulate a launch by shake a rocket a timer start follow 2G-force condition figure 37-38 and simulate release condition over 14 second figure 39 A table show Mills which is mill-second since switch on , accelerate in 3 axis and vector of it , temperature , pressure , altitude form sea-level. Releasing process figure 40-42

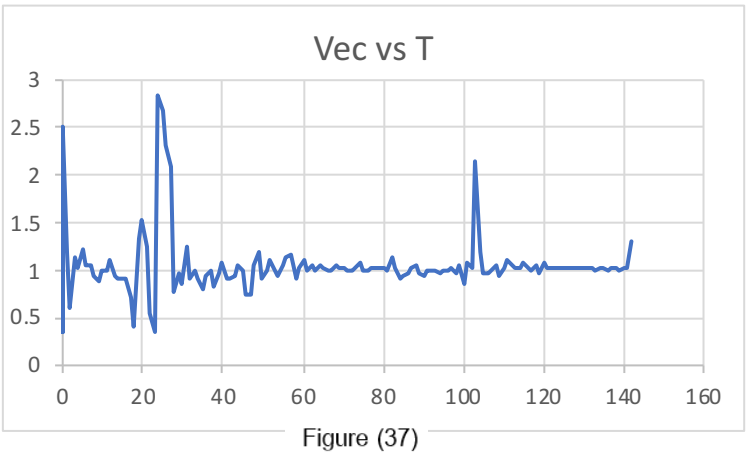


Figure (37)

Millis	T	AX	AY	AZ	Vec	ReMPU	ReMER	Temp	Press	Alt
591	0	0.97	-0.22	-0.04	1	0	0	33.83	1008.1	96.04
704	0	0.77	-0.26	0.11	0.82	0	0	33.83	1008.1	96.04
803	0	0.79	0.19	-0.15	0.82	0	0	33.83	1008.1	96.04
904	0	1.08	0.1	-0.24	1.11	0	0	33.78	1008.03	96.63
1004	0	1.58	0.35	-0.41	1.67	0	0	33.78	1008.03	96.63
1103	0	0.75	0.39	-0.24	0.88	0	0	33.78	1008.03	96.63
1205	0	0.55	0.53	-0.01	0.76	0	0	33.78	1008.03	96.63
1305	0	0.19	0.14	-0.26	0.35	0	0	33.78	1008.03	96.63
1404	0	1.94	0.31	-1.32	2.36	0	0	33.78	1008.04	96.57
1505	0	1.45	-0.77	-1.89	2.51	0	0	33.78	1008.04	96.57
1605	1	0.56	0.37	-0.99	1.19	0	0	33.78	1008.04	96.57
1704	2	0.44	0.39	0.05	0.59	0	0	33.78	1008.04	96.57
1805	3	0.91	0.65	-0.14	1.13	0	0	33.78	1008.04	96.57
1904	4	0.89	0.5	-0.05	1.02	0	0	33.78	1008.05	96.52
2004	5	1.04	0.65	-0.12	1.23	0	0	33.78	1008.05	96.52
2105	6	0.65	-0.81	-0.03	1.04	0	0	33.78	1008.05	96.52
2205	7	0.61	-0.64	0.57	1.05	0	0	33.78	1008.05	96.52
2304	8	0.61	-0.71	-0.02	0.93	0	0	33.78	1008.05	96.52

Figure (38)

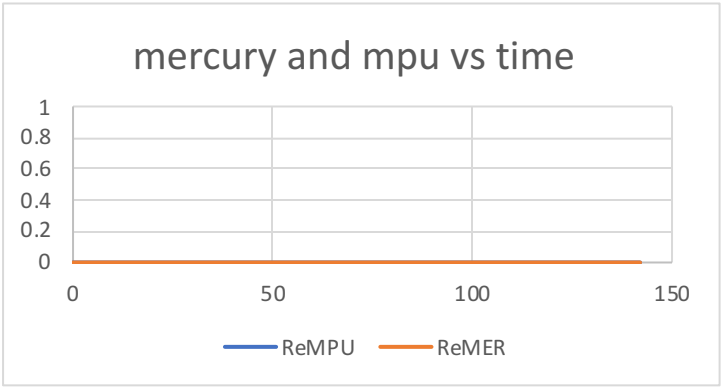


Figure (40)

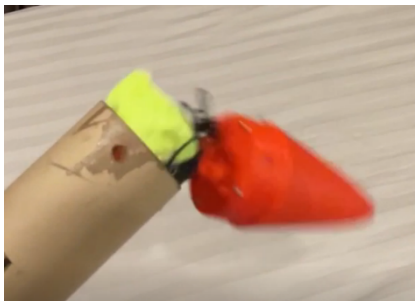


Figure (41)

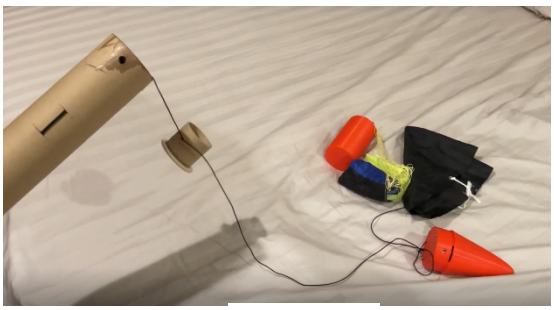


Figure (42)

Simulate The device in MPU condition by after snake over 2G-force hold device upside-down result device able to change into release stage shown as figure 43-44

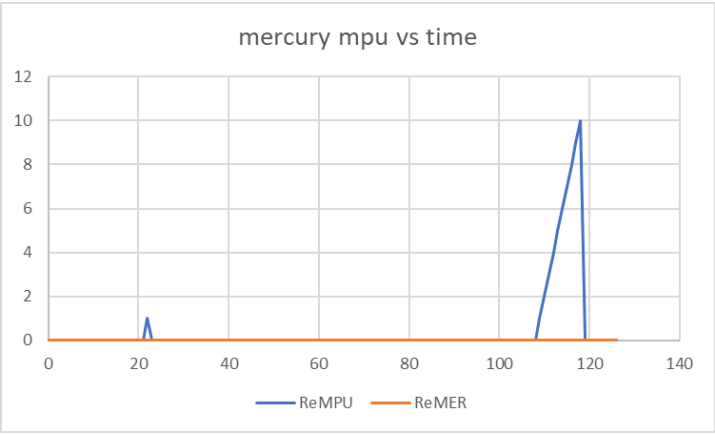


Figure (43)

Millis	T	AX	AY	AZ	Vec	ReMPU	ReMER	Temp	Press	Alt
86804	104	0.64	0.97	-0.34	1.22	0	0	36.53	1008.08	96.23
87005	106	0.73	0.63	-0.36	1.03	0	0	36.53	1008.08	96.23
87105	107	-0.16	-0.24	-0.06	0.3	0	0	36.53	1008.08	96.23
87203	108	-0.07	-0.2	-0.05	0.21	0	0	36.54	1008.08	96.21
87304	109	0.02	-0.2	0.02	0.2	1	0	36.54	1008.08	96.21
87404	110	-0.01	-0.14	0.07	0.16	2	0	36.54	1008.08	96.21
87504	111	-0.04	-0.1	-0.01	0.1	3	0	36.54	1008.08	96.21
87605	112	-0.05	-0.19	-0.01	0.2	4	0	36.54	1008.08	96.21
87705	113	0.02	-0.14	0.02	0.15	5	0	36.56	1008.08	96.25
87804	114	-0.09	-0.11	-0.02	0.14	6	0	36.56	1008.08	96.25
87905	115	-0.13	-0.05	0.03	0.14	7	0	36.56	1008.08	96.25
88005	116	0	-0.11	0.04	0.11	8	0	36.56	1008.08	96.25
88104	117	-0.04	-0.17	0.05	0.18	9	0	36.56	1008.08	96.25
88205	118	-0.05	-0.09	0	0.1	10	0	36.57	1008.08	96.23
88305	119	-0.07	-0.04	0.19	0.21	0	0	36.57	1008.08	96.23
88404	120	0.1	0.26	-0.06	0.28	0	0	36.57	1008.08	96.23
88505	121	0.15	-0.11	-0.33	0.38	0	0	36.57	1008.08	96.23
88605	122	0.5	-0.19	-0.64	0.84	0	0	36.57	1008.08	96.23

Figure (44)

on launch field the device able release payload and recovery system out in different condition first rocket release by mercury switch or 14second timer figure 45,47 rejection know by altitude incress instantly in yellow hightlight figure 47 because altitude incress instantly twice and it possible both condition but it surely doesn't release but MPU condition , Althought ReMPU detect aceleration under 0.2 G-Force over 300ms but it before 8 second noise so it doesn't release. test rocket figure 46

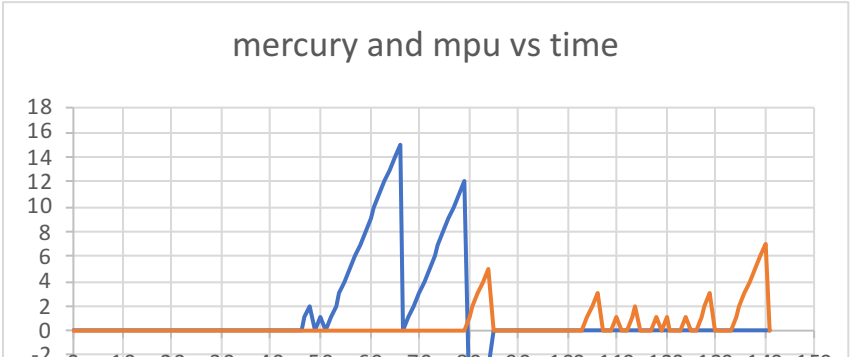


Figure (45)

Figure (46)

Millis	T	AX	AY	AZ	Vec	ReMPU	ReMER	Temp	Press	Alt
138704	134	-0.85	-0.62	0.2	1.07	0	1	40.62	961.63	491.58
138804	135	-0.51	0	0.1	0.52	0	2	40.62	961.63	491.58
138904	136	-1.2	-0.08	0.52	1.31	0	3	40.62	961.63	491.58
139005	137	-1.14	-0.9	0.06	1.45	0	4	40.62	961.63	491.58
139105	138	-1	-1.06	-0.28	1.48	0	5	40.63	960.72	499.42
139205	139	-0.82	-0.65	0.19	1.07	0	6	40.63	960.72	499.42
139305	140	-0.89	0.04	-0.16	0.91	0	7	40.63	960.72	499.42
139405	141	-1.06	-0.31	-0.04	1.11	0	0	40.63	960.72	499.42
139504	142	-1.05	-0.6	0.15	1.22	0	0	40.63	960.72	499.42
139604	143	-1.36	-0.56	0.94	1.75	0	0	40.64	959.91	506.52
139704	144	-1.62	-0.13	0.79	1.81	0	1	40.64	959.91	506.52

Figure (47)

Second rocket was release mercury switch condition figure 48-49 unfortunately the jerk-force from shock cord after rejection would cause a disconnect wire between PCB and SD card module so we cant log data after T 84 .Rocket body Figure 50-51 is before and after launch. Release process figure 52-54

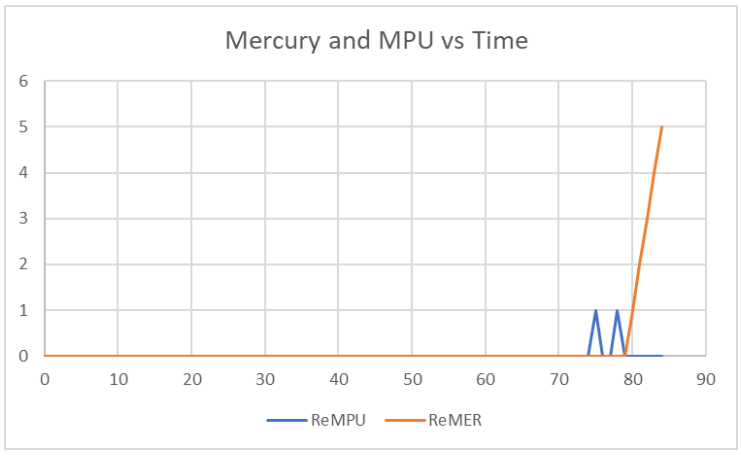


Figure (48)

Millis	T	AX	AY	AZ	Vec	ReMPU	ReMER	Temp	Press	Alt
62105	76	-0.03	0.18	-0.12	0.22	0	0	29.42	986.27	280
62203	77	-0.06	0.19	-0.07	0.21	0	0	29.43	984.96	291.13
62305	78	-0.05	0.16	-0.09	0.19	1	0	29.43	984.96	291.13
62405	79	-0.06	0.17	-0.11	0.21	0	0	29.43	984.96	291.13
62503	80	-0.09	0.19	-0.07	0.22	0	1	29.43	984.96	291.13
62605	81	-0.04	0.2	-0.09	0.22	0	2	29.43	984.96	291.13
62705	82	-0.07	0.15	-0.12	0.2	0	3	29.45	983.74	301.55
62804	83	-0.1	0.17	-0.08	0.22	0	4	29.45	983.74	301.55
62905	84	0.01	-0.09	-0.19	0.21	0	5	29.45	983.74	301.55

Figure (49)

Figure (50)

Figure (51)

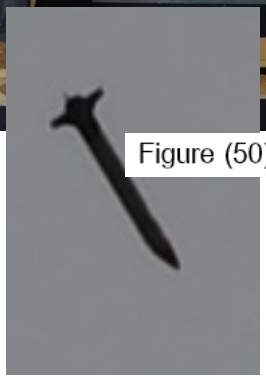


Figure (52)

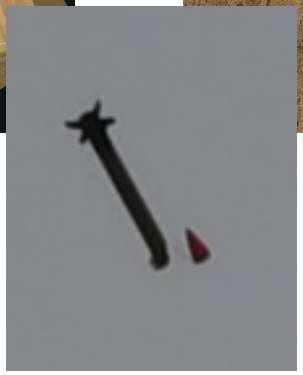


Figure (53)

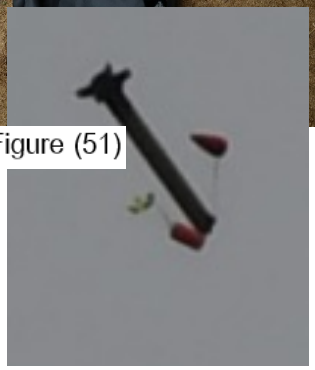


Figure (54)

Conclusion and recommendation

In conclusion The device able to release a payload and recovery system in three condition. Mercury switch , under 0.2 G-force and 14 second timer. And can detect a launch by aceleration over 2.0G-force over 200ms and eliminate a noise cause from ignition by wait 8 second or till engine burnout. This device will be a alternative choice for rejection system. Advantage of Lock and Gate method it doesn't cause explosive impact or flame , it is reusable , safe to construction ,no need to be a specialist . on the other hand it cant use in high altitude cause material characteristic , have to use force which could cause damage to payload in packing produce , have more mass and need lager than Propellant Grain

- Recommendation

This device is currently designed for a sugar rocket which is low altitude rocket. Try to make it work in higer altitude.

Combile a SD card module into PCB so don't have risk of wire disconnect also decressing size and mass.

Make a lock spot for PCB and battery inside nose cone.

Upgrade a sensor to be more accuracy especially pressure sensor for calculate altitude.

Changing material to be lighter

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Figure 20 https://www.twi-global.com/technical-knowledge/faqs/what-is-pla#Properties

Appendix

- co-developer Suwijak Mapitakkit [1], Kraiwit Charojrochkul [2], Kantapong Premyodin [3], Panithi Rungsuwankit [4], Tirawat Pintusopon [5], Suchanat Ratanarueangrong [6], Sira Kongsiri [7], Chanatan sukhochaiwanich [8], Anawach Anusurain [9]

-source code

```
#include <SparkFunMPU9250-DMP.h>
#include <Adafruit_BMP280.h>
#include <Servo.h>
#include <SPI.h>
#include <SD.h>
File myFile;
#define chipSelect 4
MPU9250_DMP imu;
Servo pin;
```

```
float aX,aY,aZ,gX,gY,gZ,vec;
Adafruit_BMP280 bmp;
bool bmpflag=1;

/***/
float zg = 0.2;
const int c = 140,o = 40;
float xcal = 0.07;
float ycal = 0.20;
float zcal = 0.11;

float gxcal = -4.68;
float gycal = -4.05;
float gzcal = 1.56;


void setup()
{
  Serial.begin(115200);
  pinMode(SS, OUTPUT);

  if (!SD.begin(chipSelect)) {
  Serial.println("SD failed!");
  }
  if (!bmp.begin()) {
    Serial.println(F("BMP280 failed"));
    bmpflag = 0;
  }
  else{
    bmp.setSampling(Adafruit_BMP280::MODE_NORMAL,     /* Operating Mode. */
                    Adafruit_BMP280::SAMPLING_X2,     /* Temp. oversampling */
                    Adafruit_BMP280::SAMPLING_X16,    /* Pressure oversampling
*/
                    Adafruit_BMP280::FILTER_X16,      /* Filtering. */
                    Adafruit_BMP280::STANDBY_MS_500);
  }
  imu.begin();
  imu.setSensors(INV_XYZ_GYRO | INV_XYZ_ACCEL | INV_XYZ_COMPASS);
  imu.setGyroFSR(2000);
  imu.setAccelFSR(2);
  imu.setLPF(20);
  imu.setSampleRate(40);
  imu.setCompassSampleRate(10);
  pin.attach(2);
  pin.write(c);
  pinMode(3,INPUT);
  myFile = SD.open("log.csv", FILE_WRITE);
  if(myFile){
    myFile.println("\nMillis,T,AX,AY,AZ,Vec,ReMPU,RePAL,Temp,Press,Alt");
    myFile.close();
  }
}

int launch = 0;
unsigned long t = 0,start;
int rempu = 0;
int repal = 0;
```

```
void loop() {
  if (imu.dataReady())
  {
    imu.update(UPDATE_ACCEL | UPDATE_GYRO | UPDATE_COMPASS);
    aX = imu.calcAccel(imu.ax)+xcal;
    aY = imu.calcAccel(imu.ay)+ycal;
    aZ = imu.calcAccel(imu.az)+zcal;
    gX = imu.calcGyro(imu.gx)+gxcal;
    gY = imu.calcGyro(imu.gy)+gycal;
    gZ = imu.calcGyro(imu.gz)+gzcal;
    vec = sqrt( pow(aX,2) + pow(aY,2) + pow(aZ,2) );
  }
  if(launch < 2 && vec >= 2) launch++;

//mpu
  if(vec <= zg && launch==2) rempu++;
  else rempu = 0;

//palord
  if(!digitalRead(3) && launch==2 && t>=80) repal++;
  else repal = 0;

  if(t==80 && rempu>3){
    rempu-=20;
  }


  String mm =
String(millis())+","+String(t)+","+String(aX)+","+String(aY)+","+String(aZ)+"
,"+String(vec)+","+String(rempu)+","+String(repal);
  if(bmpflag) mm +=
","+String(bmp.readTemperature())+","+String(bmp.readPressure()/100)+","+Stri
ng(bmp.readAltitude(1019.66));
  mm += ","+String(gX)+","+String(gY)+","+String(gZ);
  myFile = SD.open("log.csv", FILE_WRITE);
  if(myFile){
    myFile.println(mm);
    myFile.close();
  }
  else Serial.println("\nerror write sd card");
  Serial.println(mm);


  if((rempu >= 3  && t>=80) || repal >= 4 || t>140){
    pin.write(o);
  }
  //else pin.write(c);
  delay(100-millis()%100);
  if(launch == 2) t++;
}
```