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Study of Different Measurement Systems and Design of Circuitry with Intensity Modulated measuring the Velocity of Projectile

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Abstract

The aircraft structures are affected by the high velocity objects. The impact force of high velocity projectile can fracture the body if the collision does not have sufficient time for deformation to occur. The velocity of the object can vary in the range from subsonic to supersonic. The objects moving with high velocity have the high pressure waves which can damage the aircraft after striking. By calculating the velocity of an object the material of aircraft structure can be made more reliable and effective so that it can absorb these pressure waves. Different measurement systems are used and in every system the triggering time is calculated when object passes through the system. The distance is fixed and time is determined so from these two variables, velocity can be calculated. In the design circuitry the Laser Beam is converted into Pulses by Intensity Modulated Scheme to overcome the problem of setting the threshold value which varies with the intensity of light variation in the day while testing. In the design circuitry the distance is kept fixed i.e. 5 cm and the object taken to interrupt is piece of black paper in cylindrical shape when it is passed between two channels gives two pulses. The pulses with duration of 7.5 ms are determined. The velocity 6.6 m/sec is calculated with this concept. Proper setup using this design will calculate the highest velocity with more accuracy.

Keywords: velocity measurement system, Optoelectronic, Aircraft Protection.

Introduction

In physics world the term velocity is important term defined as

V= d/t

V= velocity

d= distance

t= time

An impact force is high force given for the short interval of time. This force sometimes can give more worst result comparative to the lower force which can be applied for longer time. At the normal speed and during perfectly inelastic collision the projectile strike with object, the object deforms and this deformation absorb most or even all of the force of the collision. There are so many causes of shocks. Among these Bird strikes and Hailstones has high probability of occurrences [1]. In September 1995 all 24 people on board a US air force (USAF) Boring E-38, were killed, when the aircraft crashed due to bird strike on take off from Elmendorf Air Force case in Alaska[2].

Many projectiles, e.g. shells, contain an explosive charge. With or without explosive charge a projectile can be designed to cause special damage, e.g. fire (thermal weapons), or poisoning (Arrow poison).

Projectiles which do not contain an explosive charge are termed kinetic projectile, kinetic energy weapon, kinetic warhead or kinetic penetration. Classic kinetic energy weapons are blunt projectiles such as rocks and round shot, pointed ones such as arrows, and somewhat pointed ones such as bullets. Among projectiles which do not contain explosives are also rail guns, coil guns, mass drivers, and kinetic energy penetrations.

All of these weapons work by attaining a high muzzle velocity (hypervelocity), and collide with their objective, releasing kinetic energy. A kinetic projectile can also be dropped from aircraft.

So, many numerical simulations has been done for analysing to protect the shielding of aircrafts structure and so many experimental testing is still required for evaluating reliable information about the damage on structures impacted by meteoroids or any other kind of object like small and medium calibre bullet [10].

Different Systems

There are many systems for measuring the velocity of objects or projectiles and they are:-

Break Paper System: The simple technique has been using thin aluminium plates [3]. The distance between two aluminium plates is divided by the difference of time, shown in figure (1). This technique gives unknown error when the aluminium plates generate unwanted vibration by striking.

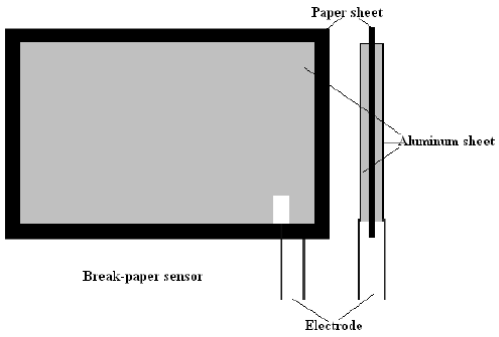

Figure 1: Break Paper System.

Inductive System: The path of the object is surrounded by circular open coil sensor. As the projectile approaches the circular open coil induces the eddy current. The output voltage increases reaching the peak level. As the object leaves the coil, the output voltage falls down [4].

The passage of conductive material induces the eddy current giving high voltage output and when the projectile completely passes the voltage reduces. The amplitude of output voltage is proportional to projectile's outer surface and sensor's inner loop. The differential sensor coil designed to suppress extraneous signals while at the same time detects the passage of the object over specific interval of time, shown in figure (2).

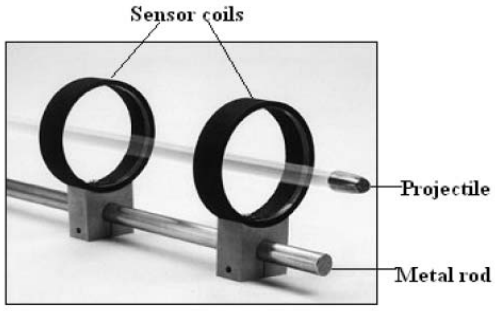

Figure 2: Inductive Coil System.

Doppler-Radar System: The object reflects the pulses with frequency shifted due to Doppler Effect, signal with a reflected return signal, to produce conventional Doppler radar [5], [6]. Each cycle of the Doppler signal represents movement of the projectile by the distance equal to half wavelength of radar signal. The typical muzzle velocity chronograph count the number of cycle occurring in the Doppler signal per unit time to determine projectile velocity.

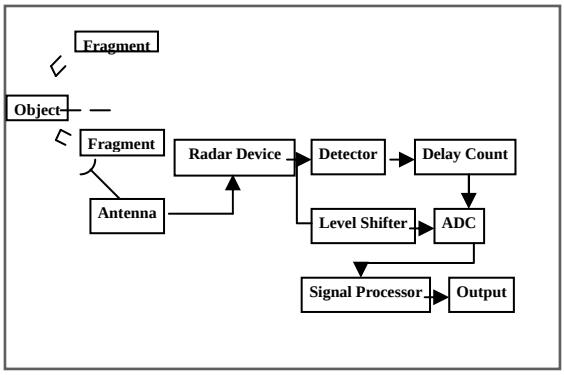

Figure 3: Block Diagram of Doppler radar System.

Photographic System: In this the counter event takes place quickly and the time for which the projectile exposes is also very small (in microseconds) [10]. The drum has stationary high speed film and sweeps the image which is reflected from rotating mirror. In this light sensitive mega pixel CMOS sensors [8] are used for acquisition of images.

Optoelectronic System: The photo detector detects the fluctuation when object passes through barriers and this dip depending on the speed of object [10]. For fast moving object the minor fluctuation amplifies by amplifier as shown in Figure (4). The system can set a voltage comparator level in the sensor circuit and compare it to photo diode sensor voltage, knowing that laser beams have been blocked by the object when the comparator state changes. This change in state creates pulses in microcontroller circuit and from the difference in pulses the time can be calculated. The distance is fixed. So velocity can be calculated. Natural light can also decrease the accuracy of the system and setting the accurate distance is also a challenge.

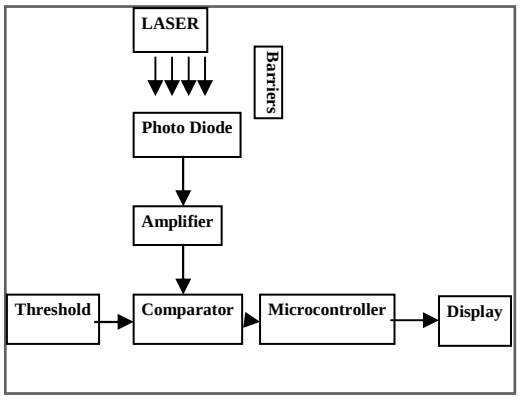

Figure 4: Block Diagram of the Optoelectronic System.

Design Circuitry

In figure (4) the comparator circuit is getting two inputs. One is from Amplifier i.e. original flip which is coming after blocking by the projectile and other input is the threshold value. Noise can be from the intensity of light or other low frequency noise. So, the threshold could not be same for the morning and the noon time. To overcome this problem new design is introduced in which the Laser Light is converted into the pulses by modulating the intensity.

The block diagram of the design circuitry is shown in figure (5). The clock is generating the pulses which is send to the Laser through pulse modulated current driver. The pulse modulated current driver basically modulates the intensity of the light as shown in Figure (6). When the pulses are missed by providing interruption to the beam, some of the pulses get missed. These missing pulses are detected by the Pulse Missing Detector (PMD

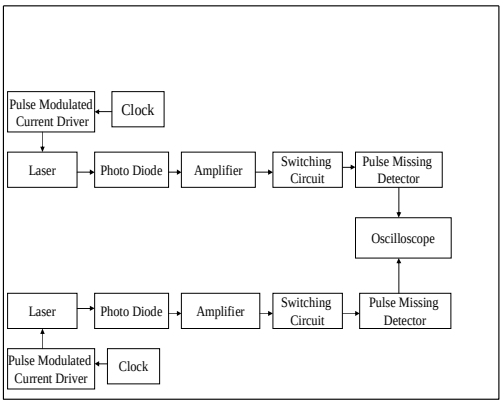

Figure 5: Block Diagram of the Design

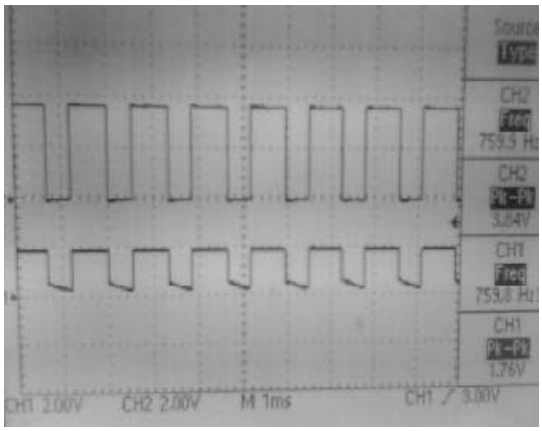

Figure 6: clock pulses and Intensity Modulated Current Driver

The laser beam in the form of pulses is received by the photodiode (PIN 404A), shown in figure (7). The photovoltaic mode is used for the reception of signal from the laser.

The signal after reception by photodiode is weak enough needed the amplification. The amplifier varies the

Output so, it is not fixed value, so to keep the value fixed between 0-5V switching is done. In Switching Circuit the AND gate is used, shown in figure (8). The output of switching circuit is same as the output of Clock Circuit.

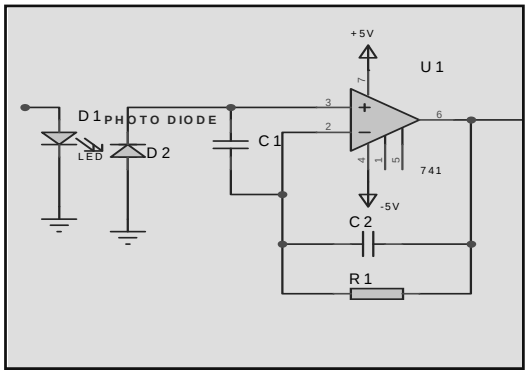

Figure 7: Circuit Diagram of Photodiode Reception.

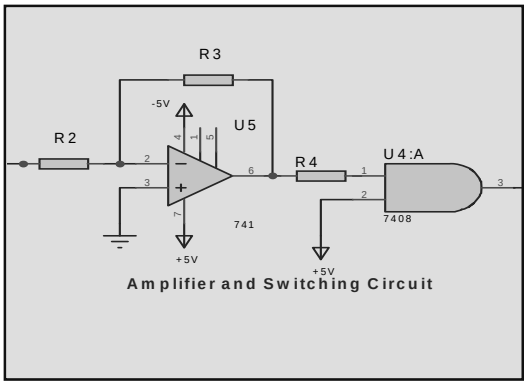

Figure 8: Circuit Diagram of Amplifier and Switching Circuit.

When the laser beam is interrupted, the switching circuit gives the output of missing pulses. These missing pulses can directly be check on the oscilloscope by putting these missed pulses to pulse missing detector, Figure (9) shows the circuit of Pulse Missing Detector

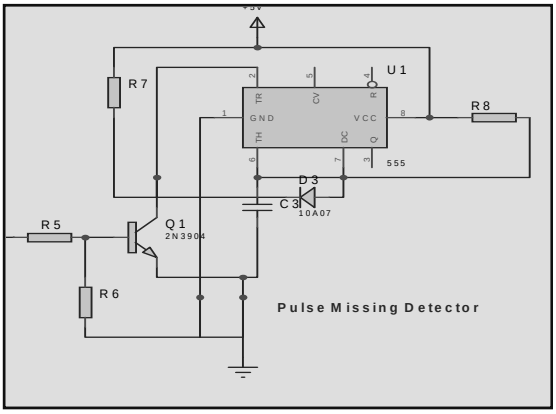

Figure 9: Circuit of Pulse Missing Detector.

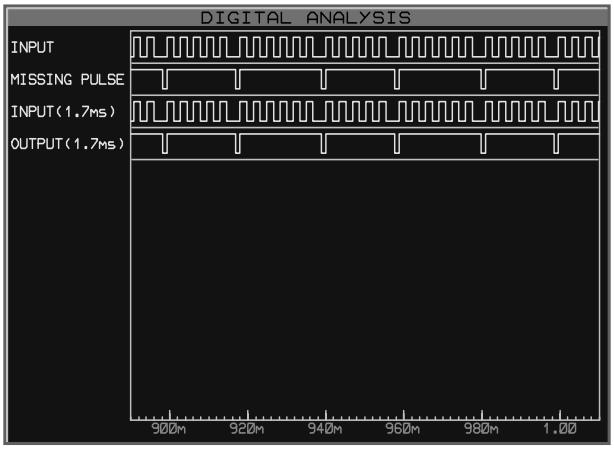

Figure 10: Output of Pulse Missing Detector.

Results

The design circuits are simulated on the Software and design on the Breadboard and output is checked on the Oscilloscope and desired output comes as shown in figure (11).

The Pulse missing Circuit shows single pulse as an output. After considering both channels two pulses can directly observed on the Oscilloscope

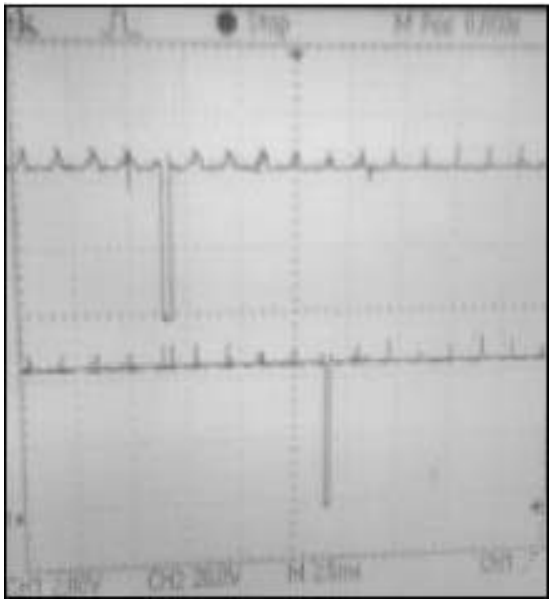

Figure 11: Result taken on the Oscilloscope.

In the design circuitry the distance is kept fixed i.e. 5cm and the object taken to interrupt is piece of black paper in cylindrical shape when it is passed between two channels gives two pulses. These pulses with duration of 7.5ms can be determined. So the velocity can be calculated as

V= d / t
V = Velocity
d = distance
t = time
V= 5cm / 7.5ms
= 6.6m/sec

Conclusion

The time can be calculated automatic with advance microcontroller for very high velocity projectiles. The fast projectiles shows small flip which might be considered as noise. This problem is also reduced with this new design.

The proper mechanical setup is in progress which will be designed using this electronic circuitry.

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Refernces

[1] A. Airoldi and B. Cacchione, "Modelling of impact forces and pressure in Lagrangian Bird strike analysis", *Int. J. Impact* Eng.32, pp. 1651-1677, 2006

[2] Australian Transport Safety Bureau, "The Hazard Posed to Aircraft by Bird", 2002.

[3] J.L. Perez – Castellanos, R. Cortes, J. Fernandez- Saez and C. Navarro, "Numerical Simulation of the Projectile on Thin Aluminum Plates," Colloque C3, Supplement au Journal de Physique 111 d' aout 1997

[4] Jimmy Q. Schmidt, Radio Frequency Coupled Differential Sensor Coil improved Muzzle Velocity Measurement, US Patent 4,486,710, 1984

[5] Yair Alon, Agoura, Calif, "Doppler Radar method and Apparatus for Measuring a Projectile's muzzle velocity", 1989

[6] Peter P. Toulios, Kenneth D. Hartman, "Doppler type projectile velocity measurement and communication apparatus and methods," US Patent 4282989, Aug. 1981

[7] M. Schneider, D .Eckenfels, and S. Nezirevic," Doppler- Radar: A Possibility to monitor Projectile Dynamics in Rail guns," IEEE Transaction on Magnetics, Vol. 39, No.1, Jan.2003.

[8] Allyson Beuhler, Francisco Castro, Anthony Polak, "CMOS Camera with Integral Laser Ranging and Velocity Measurement," US Patent 6,860,350 B2, March 2005.

[9] Charles E. Hardy," Infrared Photo detector Apparatus for the Measurement of Velocity," US Patent 6,414,747 B1, July 2002

[10] Jose M. Sanchez-Pena, Maria Y. Fernandez, Ramon Zaera, "Cost-effective optoelectronic system to measure the projectile velocity in high–velocity impact testing of aircraft and spacecraft structural elements," Optical Engineering, vol.46 (5), May 2007

[11] R.C Kalonia, Gautam Mitra, Amod Kumar, " Laser- based projectile speed measurement system," Optical Engineering 46(4), 044303, April 2007.

[12] Darlene Starratt, Tim Sanders, Elvis Cepus, Anoush Poursartip, Reza Vaziri, "An efficient method for continuous measurement of projectile motion in ballistic impact experiment," International Journal Of Impact Engineering 24 (2000) 155-170.

[13] Prof. Soni Chaturvedi, Ms Vaishali Tehere V, Dr. S.S. Limave S.S," Embedded System for Velocity Measurement of Projectile," First International Conference on Emerging Trends in Engineering and Technology, pp 1321-1324, July 2008

[14] Aseem Singh Rawat and Nitin O. Kawade, "Optical Technique for High Speed Measurement," Laser and Plasma Technology Division, DRDO Hydrabad.