Group 14

Derek Burney
Barnabas Fekete
Jason Hood
Fred Nguyenloc

Project Sponsor

Dr. Joel House

Laser Photodiode Receiver Module

Operations Manual

Table of Contents

Introduction……………………………………………………………………………3

System Components…………………………………………………………………5

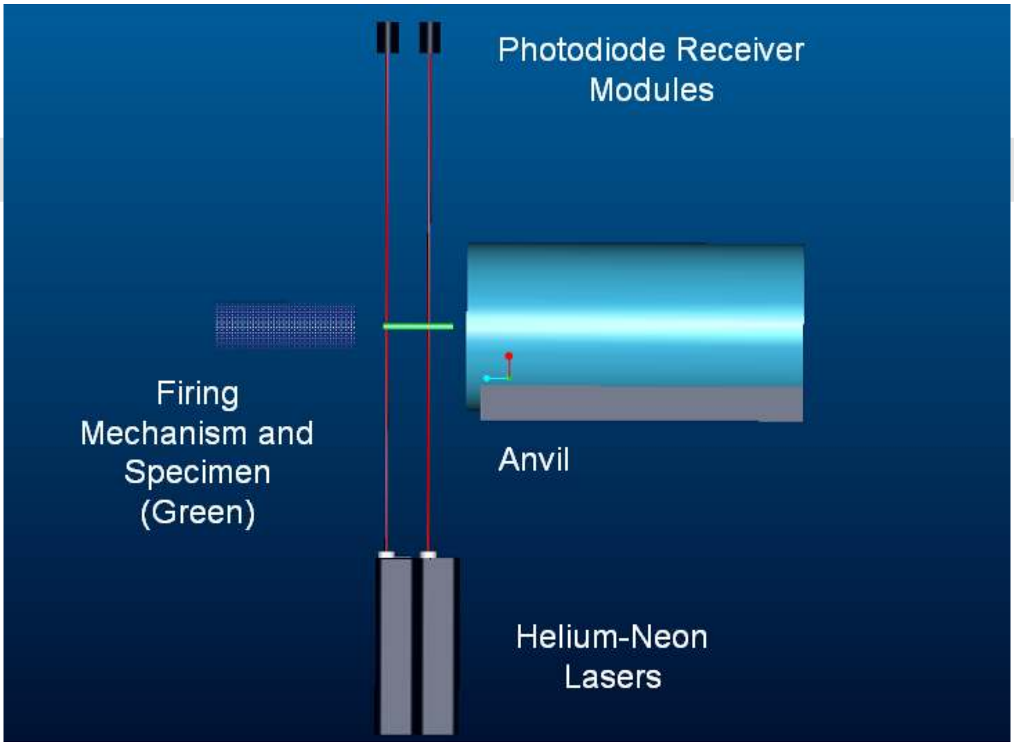
Setup Procedures……………………………………………………………………..8

Maintenance and Usage…………………………………………………………10

Introduction

The purpose of photo-diode detectors is for non-contact velocity measurement use at a ballistic range. Non-contact eliminates the problems occurring with using break wires or foil barriers (A previously popular method of limited contact velocity measurement) including stretching of the wires, redirection of the principle, and effect on the projectile. However the system works on the same principle, by choosing two points along the path of the projectile the distance at the two points in relation to time can be tracked. Knowing the distance between these two points allows measurement of velocity. The photo-detector system uses two "optical barriers" each of which trigger a response when broken, this in tern gives two points in time at which each barrier is broken by the projectile, the known distance between the barriers makes it possible to measure velocity of the projectile passing though the barriers.

The system is composed of two photo-detectors optimized to a certain wavelength of light through the use of filters. The photo-detectors are designed to give a constant voltage reading when impeding light is detected by the photo-diode surface. When the light is blocked a negative spike occurs. Two helium-neon lasers with wavelengths of 650nm are used as the incident light source. Each laser is aligned with the detector such that the photo-diode is flooded with red light; each optical barrier consists of a laser pointing into a photo-diode receiver optimized for red-light use. Once the "optical barriers" are placed along the path of the projectile, each is blocked at a certain time throughout the projectiles flight. This results in a rapid decrease in the output voltage providing an electrical signal indicating the passage of the projectile. These spikes can also be used to trigger a high speed camera used in the Taylor Impact Experiment.



(Fig 1). Basic setup of the photo-diode optical barrier system, as the projectile (green) passes thought each of the two laser barriers (red), an electronic response from the breaking of the barriers with relation to time gives accurate velocity measurement.

The signal output of each photo-diode detector is analog and can be recorded on either an oscilloscope or a data acquisition system (DAQ) attached to a computer. However, a high sample rate of the DAQ is required.

In ballistic experiments, debris from firing often accompany the projectile, The design of each photo-diode detector facilitates, the negative voltage spike is directly proportional to the amount of incident light on the detector surface, therefore smaller debris would cause spikes in the data acquisition process, however these spikes would be negligible with comparison to those of the projectile itself. Caution must be taken to minimize disturbance of the data acquisition from debris, so it is recommended that the work area and gun barrel be cleaned frequently; preferably proceeding each experiment.

The following makes this photo-diode detection system very useful in the Taylor Impact Test for which it was designed for, in offering a simple, reliable, and accurate method of velocity measurement.

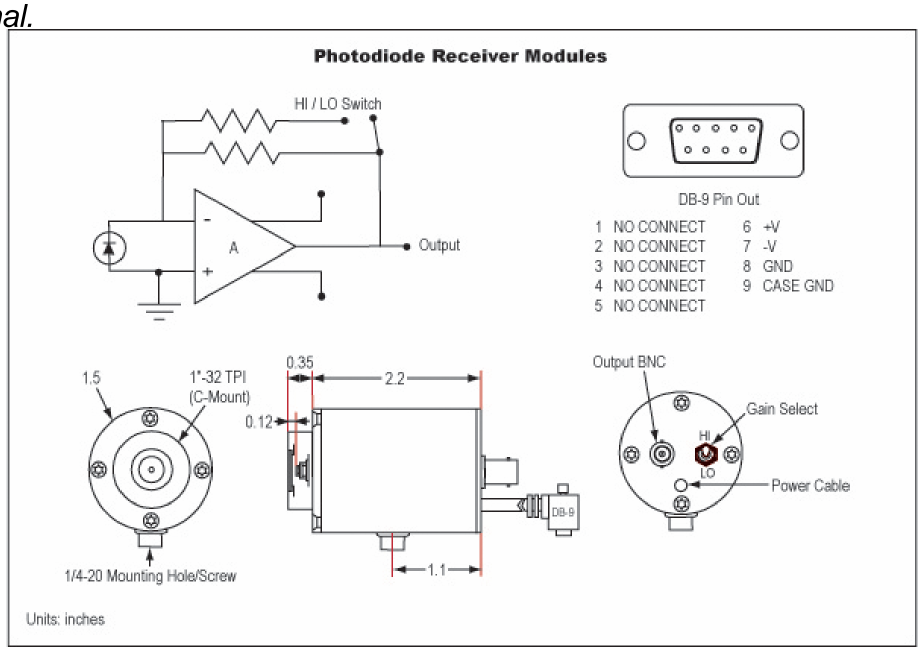
Description of Components

The photo-diode detectors used in this system are Edmund Optics photodiode receiver modules with optimized red-light filters. Each of the two photodiode receiver modules requires a power supply and BNC style signal cables. Two helium-neon lasers are recommended to complete the installation of the system. Along with the primary components a 12V 2-channel power supply operating at 115V at 60Hz and a bracket system for mounting the photodiodes to the current system is provided.

Photodiode Receiver Module

Quantity: 2

The photodiode receiver modules are provided by Edmund optics (fig.2), they are housed in a cylindrical aluminum housing, Each has a receiving lens which will be exposed to the incident laser light source, a threaded section for installation of filters (red light optimized in this application). A mounting screw with corresponding threaded hole is provided on the side of each casing for ease of installation. The top of each housing provides a 2-position gain selector switch, a power cable, and a BNC connector providing analog signal.



(Fig.2) Edmund Optics photodiode receiver modules
(Schematic property of Edmund Optics)

Red light Filters

Quantity: 2

Photodiodes are optimized for a certain range of light wavelengths; however this range is usually very large. The photodiodes used in the Edmund Optics receiver modules covers most of the visual spectrum. To prevent ambient lighting from saturating the detectors red-light filters are used. These filters only allow the red light spectrum to be detected by the unit, therefore optimizing output for use with the helium neon lasers recommended for use with the system. These filters simply screw on to the lens portion of the detector.

Power Supply

Quantity: 1

The 2-channel 12 v power supply provided with the system provides the system with amplification necessary to make the voltage changes from the photodiodes detectable, fig.3 provides specifications of the power supply. The photodiode receiver modules are connected using DB-9 pin connectors; the power supply connects to conventional 120 v AC power. A rear mounted switch is used to power the unit on or off.

Dual ended BNC cable

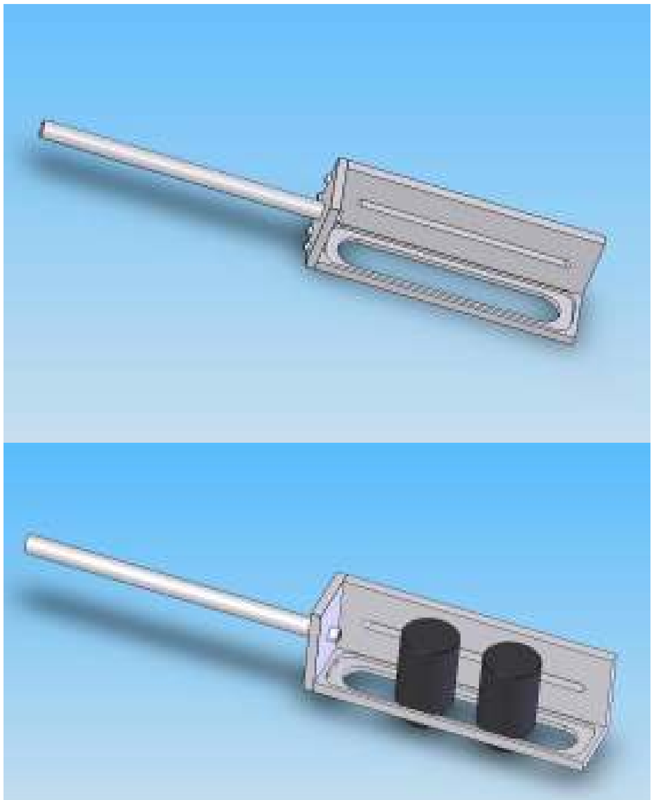
Quantity: 2

Cables are used to connect photodiode receiver modules to the data acquisition system capable of receiving analog signal to 13V. To simplify installation, original BNC wiring from previous setup may be re-used.

Mounting Fixture

Quantity: 1

The mounting brackets as shown in (fig.4) were designed to integrate into the pre-existing system. The design eliminates movement in all but 1 degree of freedom in linear translation. The bracket is machined in an L shape and provides a machined track to hold each receiver-module, each module can be moved along the track so as to adjust the system, a mounting screw is installed though the rear-track when the position of the detectors is satisfactory. The rod end is clamped into the current mount and can be freed in a linear fashion, as well as in rotation to make laser alignment simple. The base of the rod mount is mobile along the (x,y) plane which allows for further flexibility in mounting.



(Fig.4) Custom mounting fixtures for Edmund Optics photodiode receiver modules.

Warning:

1. ***Never* stare directly into any laser regardless of power, as retinal damage may occur**
2. ***Always* power down the unit before connecting or disconnecting any BNC connectors or making any gain adjustments on the detectors.**
3. ***The power supply is capable of both 120v and 220v; make sure the power selector switch is in the correct configuration before connecting the power.***
4. ***Only* use the provided mounting screws or equivalent length, using screws which are too long will cause damage to the internals of the detector.**
5. ***Assure* that the data acquisition system is compatible with 13V; otherwise damage to the data acquisition system may occur.**
6. ***Assure* the power outlet is grounded. Removal of the grounding post and/or bypassing the ground is not recommended.**
7. ***Use only* class II or lower laser products.**

Setup:

1. Attach the new bracket system to the current mounting system by installing the rod into the holder, clamp down lightly to hold in place. Install each Edmund optics photodiode receiver module individually into the bracket, sliding the detector into the bracket may take a slight amount of force, each detector should snap firmly into the machined track.

2. Once in the track rotate the detector so the mounting hole on the side lines up with the mounting screw track along the side of the bracket. Repeat this step for the other Edmund optics Receiver module, hand threading of the mounting screw in the mounting bracket should keep everything aligned while moving the detectors along the track (thread the screws in loose.)

3. Level the bracket in the rotational direction and hand tighten the rod holder to prevent the bracket from rotating.

4. Connect the BNC connectors to the detectors and to the corresponding channel on the data acquisition means (a BNC splitter may be used for triggering of high speed camera.) Connect each unit to the power supply tightening down the corresponding holding screws, plug the power supply on and power on the unit.
5. Assuming the lasers have been mounted in the appropriate positions in centered path of the projectile, align each photodiode module so the beam is centered in the photodiode window (an opaque piece of paper can make this process easier in high light environments.)
An alternate and more precise method of assuring alignment is viewing the steady voltage on each detector as the detector is aligned, when voltage is at its highest the detector is aligned.
Once alignment is sufficient tighten the corresponding mounting screw snugly to hold the detector in place, ***Do Not Over-tighten***.
6. Install one filter on each of the Edmund Optics photodiode receivers being careful not to effect alignment of the bracket. The base of each photodiode lens is threaded and should stick out past the bracket, thread on each filter snugly by hand, ***Do Not Over-tighten***.
7. Using an opaque object block each laser barrier noting the response on the data acquisition system. Due to the high speed nature of Taylor impact testing the gain should be set at the lowest setting (switch position towards the mounting screw.) which will give the quickest response time. Each detector should register approximately 13 V unblocked, blocking the laser barrier should cause a spike in the negative direction (close to or at 0 v). If this is not the case double check laser/photodiode alignment as well as all connections.

The Setup of the detectors is now complete

Maintenance and Usage:

The Edmund Optics photodiode receiver modules are housed in aluminum casings, along with an effective and sturdy bracket system should be relatively maintenance free. However certain precautions must be taken to increase the life of the detectors. ***The highest power lasers that should be used in this configuration is class II*** as it is advised that any laser product of higher class may cause pre-mature failure of the photodiode receivers. Proper precautions need to be taken to protect the modules from debris as well as projectiles due to ballistic testing, it is recommended that the photodiodes be encased in a protective enclosure or used at a distance great enough to minimize the risk of damage to the lens or filter. The current ballistics testing is encased in a steel enclosure when testing is done to prevent damage to high speed cameras. The photodiode receiver modules should be mounted outside the enclosure, modifications can be made to the enclosure to allow for the laser barriers to be unaffected by the enclosure.

The lenses of the receiver modules should be cleaned regularly using optical grade cleaning products. Due to the nature of ballistics experiments and the high particulate matter associated with them it is recommended that the lenses be cleaned frequently.

Moisture can corrode the detectors circuitry, as well as the power supply, it is crucial that moisture is minimized for increased service life.

Lasers and photodiodes have a limited service life, it is recommended that photodiodes be replaced every 5 years, Lasers should be replaced according to the manufacturer of the specific product.