DEFENCE RESEARCH AND DEVELOPMENT ORGANISATON (DRDO)

SUMMER INTERNSHIP PROJECT REPORT

at
LASER SCIENCE AND TECHNOLOGY CENTRE (LASTEC)

LASTEC
Defence Research and Development Organization
Metcalfe House, Delhi -110054

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CERTIFICATE

Certificate No.: 2019684

लेज़र विज्ञान एवं प्रौद्योगिकी केन्द्र

LASER SCIENCE & TECHNOLOGY CENTRE

रक्षा अनुसंधान एवं विकास संगठन

DEFENCE R & D ORGANISATION

प्रमाण पत्र

CERTIFICATE

This is to certify that ~~Miss~~/Mr. JOYDEEP SEN GUPTA *a student of* HMR INSTITUTE OF TECHNOLOGY & MANAGEMENT *has worked on the project "* LASER DIODE DRIVERS FOR FIBER LASERS & DAC SOFTWARE *under the guidance of Ms/~~Mr.~~* ALKA SAHNI *Scientist* F *at Laser Science and Technology Centre (LASTEC), Metcalfe House, Delhi, Defence Research and Development Organisation (DRDO) during the Internship period from* 7th JUNE, 2019 *to* 29th JULY, 2019

~~She~~/He has successfully completed the Internship and submitted a technical project report for the same.

अलका साहनी

Divisional Head

DPAL *Division*

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कृते निदेशक/For Director
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DECLARATION

I the undersigned solemnly declare that the project report is based on my own work carried out during our study under the supervision of Dr. Alka Sahni.

I assert the statements made and conclusions drawn are an outcome of my research work. I further certify that:

I. The work contained in the report is original and has been done by me under the general supervision of my supervisor.
II. The work has not been submitted to any other Institution for any other degree/diploma/certificate in this university or any other University of India or abroad.
III. We have followed the guidelines provided by the university in writing the report.
IV. Whenever we have used materials (data, theoretical analysis, and text) from other sources, we have given due credit to them in the text of the report and giving their details in the references.

PROJECT TEAM

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ACKNOWLEDGEMENT

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We are highly indebted to Defense Research and Development Organization (DRDO) for their guidance and constant supervision as well as for providing necessary information regarding the project & also for their support in completing the project.

We would like to express our gratitude towards the scientists of LASTEC for their kind co-operation and encouragement which help us in timely completion of this project.

Last but not the least, we would like to express our special gratitude and thanks to scientists Dr. Alka Sahni and Mr. Himanshu Rai for giving us such attention and time, and furthermore guiding us throughout the project with patience and perseverance.

ORGANISATION PROFILE

Defence Research & Development Organisation (DRDO) works under Department of Defence Research and Development of Ministry of Defence. DRDO dedicatedly working towards enhancing self-reliance in Defence Systems and undertakes design & development leading to production of world class weapon systems and equipment in accordance with the expressed needs and the qualitative requirements laid down by the three services.

DRDO is working in various areas of military technology which include aeronautics, armaments, combat vehicles, electronics, instrumentation engineering systems, missiles, materials, naval systems, advanced computing, simulation and life sciences. DRDO while striving to meet the cutting edge weapons technology requirements provides ample spinoff benefits to the society at large thereby contributing to the nation building.

Vision

Make India prosperous by establishing world-class science and technology base and provide our Defence Services decisive edge by equipping them with internationally competitive systems and solutions.
DRDO has many research and development labs spread across the country. The different R&D labs are meant to work on different projects. One of the labs of DRDO is LASTEC (Laser Technology Laboratory).

Laser Science & Technology Centre (LASTEC), Delhi has its origin as Defence Science Laboratory (DSL) established as a nucleus laboratory of DRDO in 1952. In the beginning DSL operated from National Physical Laboratory (NPL) building. Later in 1960, it was shifted to Metcalfe House. In 1982, the DSL moved to its new technical building in Metcalfe House complex and was renamed as Defence Science Centre (DScC). In 1999, in view of the R&D thrust shifting to development of lasers and optoelectronics systems & related technologies, the laboratory was rechristened as Laser Science & Technology Center (LASTEC). With time, many of DSL activities were given to newly formed, specialised DRDO laboratories. DSL has served as a precursor for as many as 15 present DRDO labs, which include DRDL, SSPL, INMAS, FRL, ISSA, DESIDOC, CFEES, SAG and ITM.

AIM 1
To study Laser Diode Drivers for Fiber Lasers

LASER

A **laser (light amplification by stimulated emission of radiation)** is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. A laser differs from other sources of light in that it emits light coherently.

Coherence is measure of the ability of different wavefronts or parts of wavefronts, to interfere or intermingle with each other, when the wavefronts are combined, as in an interferometer. As such, coherence can also be termed as the measure of the ability of two photons to interfere or intermix with each other.

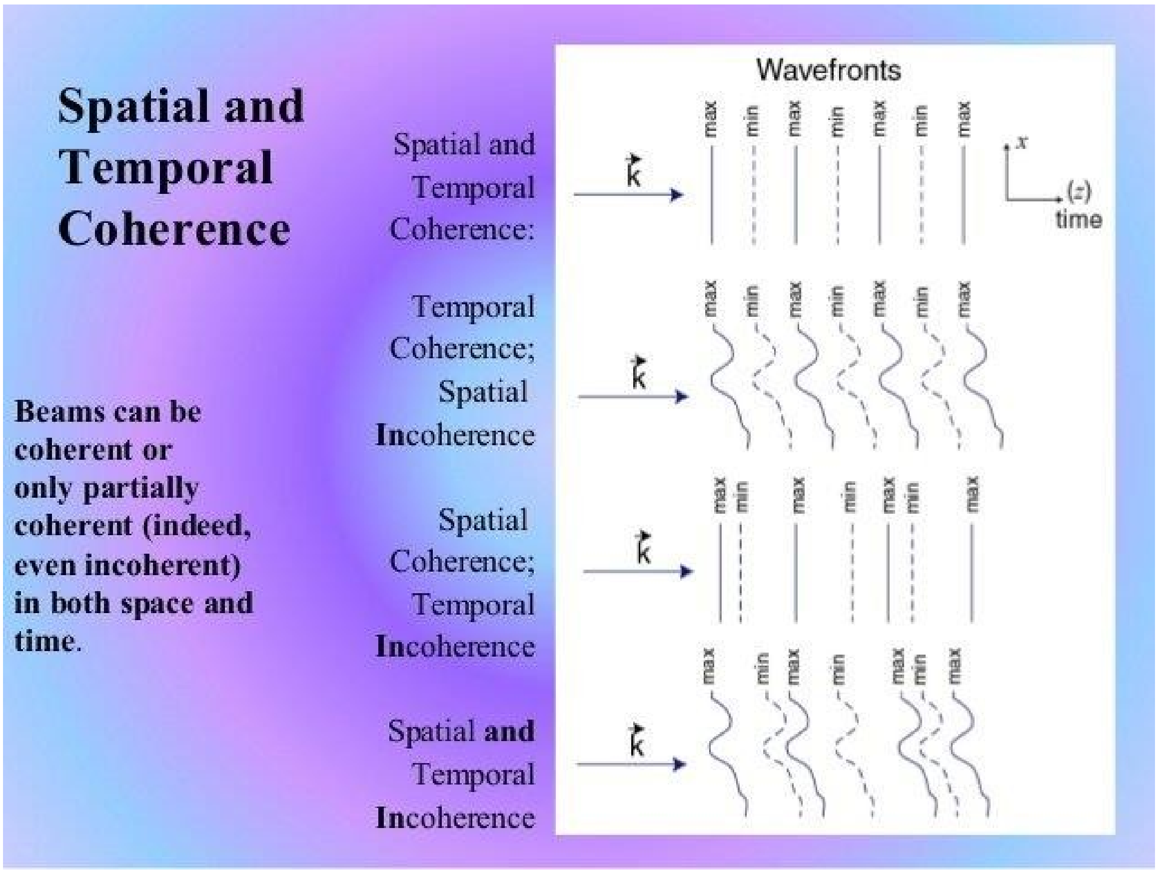
There are two types of coherence which are as follows:-

1) Spatial Coherence

Spatial coherence allows a laser to be focused to a tight spot, enabling applications such as laser cutting and lithography. Spatial coherence also allows a laser beam to stay narrow over great distances (collimation), enabling applications such as laser pointers and LIDAR.

2) Temporal Coherence

Lasers can also have high temporal coherence, which allows them to emit light with a very narrow spectrum, i.e., they can emit a single color of light. Alternatively, temporal coherence can be used to produce pulses of light with a broad spectrum but durations as short as a femtosecond ("ultrashort pulses").



BRIGHTNESS AND INTENSITY

Brightness of a source of light is the power emitted per unit area per unit solid angle. Let ∂A be the elemental surface area at a point O of the source of light. The power ∂P emitted by area ∂A into a solid angle ∂S, around the direction OO'

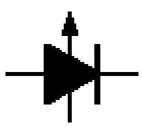
$$\partial P = B\cos\Theta\,\partial A\,\partial S$$

Where ,Θ is the angle between OO' and the normal n to the surface.The quantity B is called the brightness of the source, at the point O, in the direction OO'.The factor $\cos\Theta$ indicates the physical importance in the projection of ∂A is a plane which is orthogonal to the OO' direction.
Laser beams are the brightest of sources. They are extremely intense too.

MONOCHROMATICITY

One of the special characteristics of a beam having temporal coherence is spectral purity or monochromatictiy. The high spectral purity of laser is due to the ability of the optical resonator to oscillate only a very small no of resonant modes. The design of the optical resonator or cavity makes most of the cavity resonant modes to fall outside the gain-curve such that only a few find the gain available to compensate for the losses. Reduction of modes in the cavity can be used to decrease the bandwidth of laser lower than a nanometer.
The output from a laser scheme is very nearly perfect to givw us a sine wave with very small bandwidth of about one Khz/sec. The output from a stable gas laser, locked to the centre of the absorption line has a bandwidth Δf approximately equal to 500 Hz which means that $\Delta l=10^{-8}$ at $l=6000$ A 0.

<u>Laser Diode: Basics and Principle</u>



A laser diode is a semiconductor device similar to a light-emitting diode in which the laser beam is created at the diode's junction. Laser diodes can directly convert electrical energy into light. Driven by voltage, the doped p-n-transition allows for recombination of an electron with a hole. Due to the drop of the electron from a higher energy level to a lower one, radiation, in the form of an emitted photon is generated. This is spontaneous emission. Stimulated emission can be produced when the process is continued and further generate light with the same phase, coherence and wavelength.

The choice of the semiconductor material determines the wavelength of the emitted beam, which in today's laser diodes range from infra-red to the UV spectrum. Laser diodes are the most common type of lasers produced, with a wide range of uses that include fiber optic communications, barcode readers, laser pointers,CD/DVD/Blu-ray disc reading/recording, laser printing, laser scanning and light beam illumination.

LASER DIODE BASICS

There are three main processes in semiconductors that are associated with light:

- **Light absorption :** Absorption occurs when light enters a semiconductor and its energy is transferred to the semiconductor to generate additional free electrons and holes. This effect is widely used and enables devices like to photo-detectors and solar cells to operate.

- **Spontaneous emission :** The second effect known as spontaneous emission occurs in LEDs. The light produced in this manner is what is termed incoherent. In other words the frequency and phase are random, although the light is situated in a given part of the spectrum.

- **Stimulated emission :** Stimulated emission is different. A light photon entering the semiconductor lattice will strike an electron and release energy in the form of another light photon. The way in which this occurs releases this new photon of identical wavelength and phase. In this way the light that is generated is said to be coherent.

PRINCIPLE

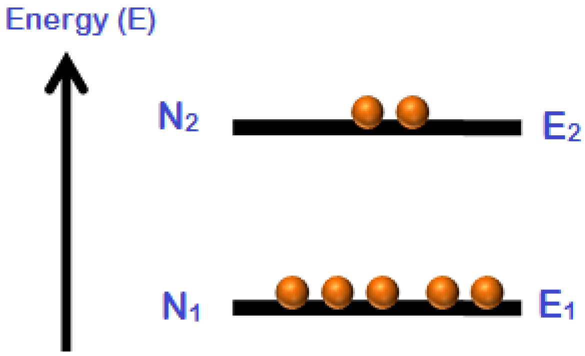
The key to the laser diode operation occurs at the junction of the highly doped p and n type regions. In a normal p-n junction current flows across the p-n junction. This action can occur because the holes from the p-type region and the electrons from the n-type region combine. With an electromagnetic wave (in this instance light) in passing through the laser diode junction diode junction it is found that the photo-emission process occurs. Here the photons release further photons of light occurs when they strike electrons during the recombination of holes and electrons occurs.

POPULATION INVERSION

Population inversion is the process of achieving greater population of higher energy state as compared to the lower energy state. Population inversion technique is mainly used for light amplification. The population inversion is required for laser operation.

Consider a group of electrons with two energy levels E_1 and E_2.

E_1 is the lower energy state and E_2 is the higher energy state.
N_1 is the number of electrons in the energy state E_1.
N_2 is the number of electrons in the energy state E_2.
The number of electrons per unit volume in an energy state is the population of that energy state.



Population inversion cannot be achieved in a two energy level system. Under normal conditions, the number of electrons (N_1) in the lower energy state (E_1) is always greater as compared to the number of electrons (N_2) in the higher energy state (E_2).

$$N_1 > N_2$$

When temperature increases, the population of higher energy state (N_2) also increases. However, the population of higher energy state (N_2) will never exceeds the population of lower energy state (N_1).

At best an equal population of the two states can be achieved which results in no optical gain.

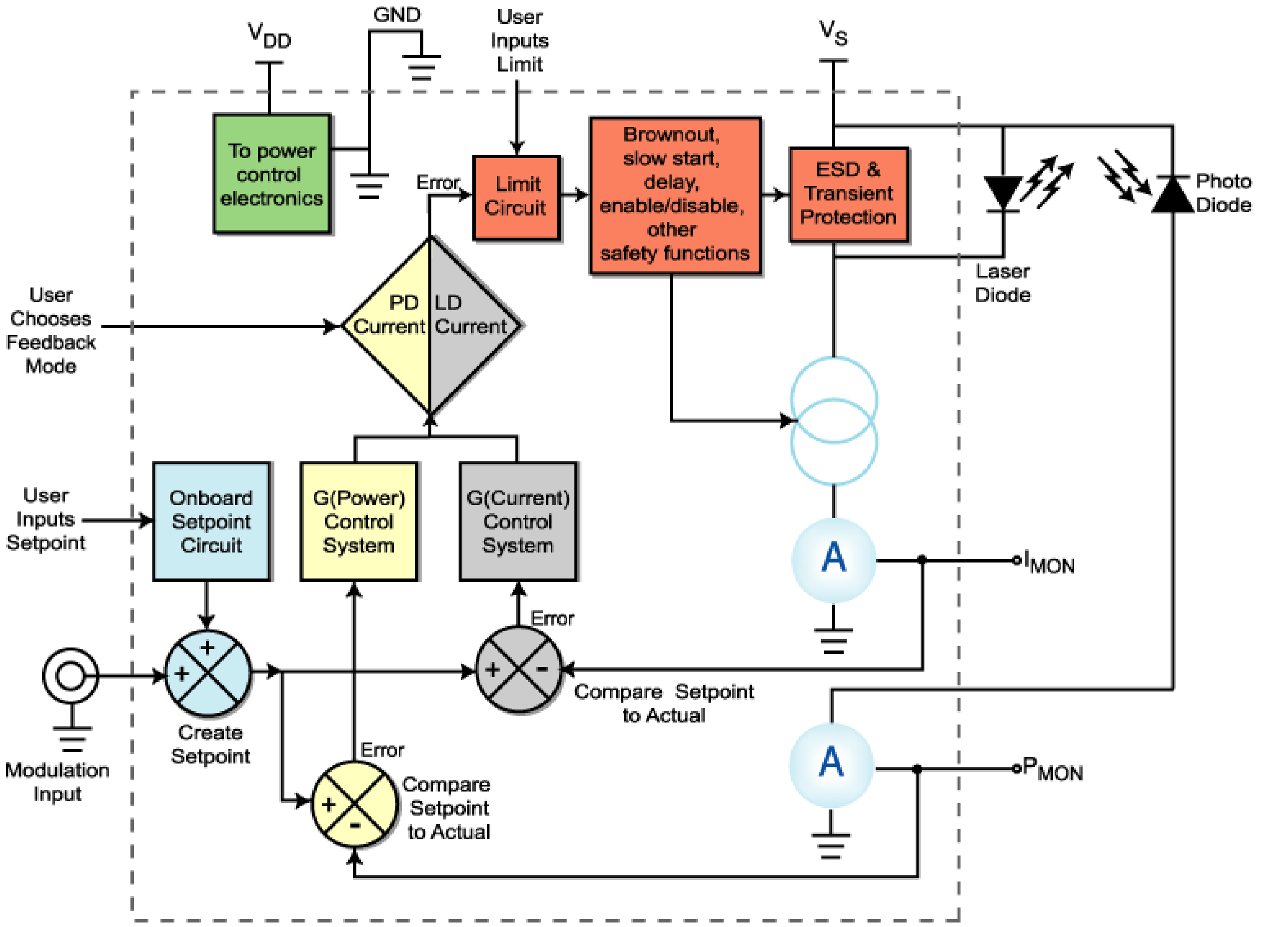
$$N_1 = N_2$$

Therefore, we need 3 or more energy states to achieve population inversion. The greater is the number of energy states the greater is the optical gain.

There are certain substances in which the electrons once excited; they remain in the higher energy level or excited state for longer period. Such systems are called active systems or active media which are generally mixture of different elements.

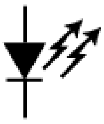
When such mixtures are formed, their electronic energy levels are modified and some of them acquire special properties. Such types of materials are used to form 3-level laser or 4-level laser.

LASER DIODE DRIVER

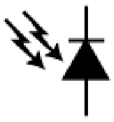


In its most ideal form, the laser diode driver is a constant current source, linear, noiseless, and accurate, that delivers exactly the current to the laser diode that it needs to operate for a particular application. The user chooses whether to keep laser diode or photodiode current constant and at what level. Then the control system drives current to the laser diode safely and at the appropriate level. The block diagram in Figure 1 shows a very basic laser diode driver (or sometimes known as a laser diode power supply). Each symbol is defined in the table below. Each section is described in detail below. Laser diode drivers vary widely in feature set and performance. This block diagram is a representative sample, meant to familiarize the users with terminology and basic elements, not an exhaustive evaluation of what is available on the market.

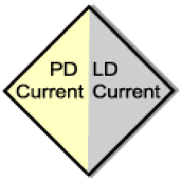
Symbol | **Name & Brief Description**



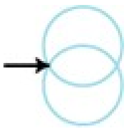
Laser Diode: The function of the Laser Diode Driver is to provide current to the laser diode. The wavy arrows indicate light exiting the package. A huge array of applications exist for laser diodes. These can include spectroscopy, remote sensing, medical diagnostic & analytical equipment, particle sizing & counting, welding & materials processing, and a myriad of other applications. It often is abbreviated as LD.



Photodiode: Sometimes, a monitor photodiode is integrated into the laser diode package. It produces a current somewhat proportional to the output laser diode optical power. Each laser diode package is different and usually the photodiode transfer function varies widely. The wavy arrows indicate light entering the package. It often is abbreviated as PD.

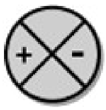


Feedback Mode: Most laser diode drivers will allow control based on either laser diode current or photodiode current. If laser diode current is used as feedback, the control system will try to keep it constant. The output of the Adjustable Current Source will not vary. This is called Constant Current Mode (or CC mode). If photodiode current is used as feedback, the control system will try to keep the photodiode current (and by extension – laser diode optical power) constant. The output of the Adjustable Current Source WILL vary to keep the optical power level the same. This is called Constant Power Mode (or CP mode).



Adjustable Current Source: Current flows through the laser diode as regulated by the current source.

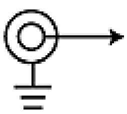
Ammeter: Current is measured through the laser diode or photodiode and translated into a voltage. IMON represents the current through the laser diode. PMON represents the current through the photodiode.



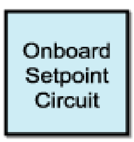
Summing Amplifier: These are used to measure the difference between setpoint and actual current, or to sum the onboard setpoint trimpot with an external analog modulation signal.

G(Power): This function represents how the error between setpoint and actual photodiode current is modified to make an electronic signal that appropriately drives the Adjustable Current Source to keep error to a minimum. It is used during Constant Power mode operation.

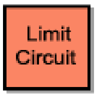
G(Current): This function represents how the error between setpoint and actual laser diode current is modified to make an electronic signal that appropriately drives the Adjustable Current Source to keep error to a minimum. It is used during Constant Current mode operation.



Modulation Input: An analog signal (e.g. a sine wave, triangle wave scan, or square wave) can be input to the laser diode driver. This voltage signal is related to the actual current or power output by a transfer function.



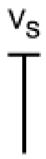
Onboard Setpoint Circuit: Since setpoint is application specific, it must be adjustable by the user. Typically, laser diode power supplies integrate an adjustment mechanism, such as a trimpot.



Limit Circuit: This section of the laser diode driver is key to protect the laser diode. The user sets the limit current based on the operating parameters of the laser diode (typically well below damage threshold). An Active Current Limit will shut off the laser diode current if the control system drive exceeds this current limit setting.

Safety Functions: While laser diode reliability has significantly improved over the years, a laser diode is still susceptible to damage in a variety of ways. These safety functions protect the laser diode as much as possible.

VDD: This symbol is used to refer to the external power supply that feeds the control electronics. In an instrument, this is not seen by the user. In a component or module, the user chooses how to power the control electronics. Usually this is low voltage – 3.3 to 5 V DC.



VS: This symbol is used to refer to the external power supply that feeds the Adjustable Current Source (or output stage) electronics. In an instrument, this is not seen by the user. In a component or module, the user chooses whether to tie the control electronics to the output stage or separate them so higher compliance voltage can be delivered. This is a DC voltage.

IMON: This symbol represents the laser diode current monitor voltage. Laser Diode current is related to this voltage by a transfer function given in the laser diode driver datasheet.

PMON: This symbol represents the photodiode current monitor voltage. Photodiode current is related to this voltage by a transfer function given in the laser diode driver datasheet. Photodiode current and laser diode output power are related by a transfer function given in the laser diode datasheet.

Laser Diode Current Source: One key section of a laser diode driver is the Adjustable Current Source. It can also be known as the Output Stage. This section responds to the Control System section by driving current to the laser diode. In the block diagram, the laser diode is between supply voltage and the current source. Other laser diode drivers put the laser diode between the current source and ground. Depending on the laser diode configuration and grounding, one approach may be better than the other. This is the section where the user wires the laser diode and/or photodiode into the circuit.

Control System: User inputs include the limit setpoint (in terms of maximum laser diode current allowed to the laser diode), the operating setpoint, and whether the control variable is laser diode current or photodiode current. Additionally, if a remote setpoint is required, an Analog Modulation Input is usually available.

- **Setpoint:** This is an analog voltage into the system. It can be created by a combination of onboard adjustment and the modulation input. In some cases, the modulation input sums with the onboard setting. In other cases, it subtracts from the onboard setting.

- **Error Generation:** To know how the system is functioning, the Actual current level is compared to the Setpoint current level. These two voltages are subtracted and the result is called the "Error." In the case of a laser diode driver, the actual current level can come from either the laser diode or the photodiode. If laser diode current is used as feedback, the control system will use the Error signal from the laser diode current. The output of the Adjustable Current Source will not vary. This is called Constant Current Mode. If photodiode current is used as feedback, the control system will try to keep the photodiode current (and by extension – laser diode optical power) constant. The output of the Adjustable Current Source WILL vary to keep the optical power level the same. This is called Constant Power Mode.

- **Control Function:** This converts the error signal into a control signal for the Laser Diode Current Source. It is not the same for Constant Power or Constant Current mode.

- **Limit Circuit:** One way to damage a laser diode is to drive too much current through it. Each laser diode datasheet will specify a maximum operating current. Exceeding this current will damage the laser diode. To avoid this, a limit circuit is included in the laser diode power supply. The user determines the maximum setting and the output current is kept from exceeding that level. Some limit circuits cap the current at the max level and keep operating. An Active Current Limit circuit will disable the laser diode driver current.

- **Safety features:** These vary widely between laser diode drivers. Worldwide, governmental regulations require a few basic elements for the more powerful laser systems. First, there must be a time delay between application of electrical power and lasing. Second, there must be a way to interlock protective housings or entry doors, so that if the housing or door is opened, the laser shuts off. Laser diodes are sensitive to thermal shock so a slow-start circuit is usually integrated. For DC powered drivers, an output shutdown when the voltage droops and threatens control integrity is called Brownout Protection. Another valuable feature can protect the laser diode against ESD shocks or transients from the power supply.

- **Power:** Power must be provided to the control electronics and current source. This can take the form of a DC power supply (some drivers use single supply inputs, others use dual supplies), or an AC input connector and cable. In some cases, where higher voltage is required to the laser diode, separate DC power supply inputs may be available to power the control electronics from a low +5 V supply and the laser diode from a higher voltage supply.

Operational Working of Laser Diode Drivers

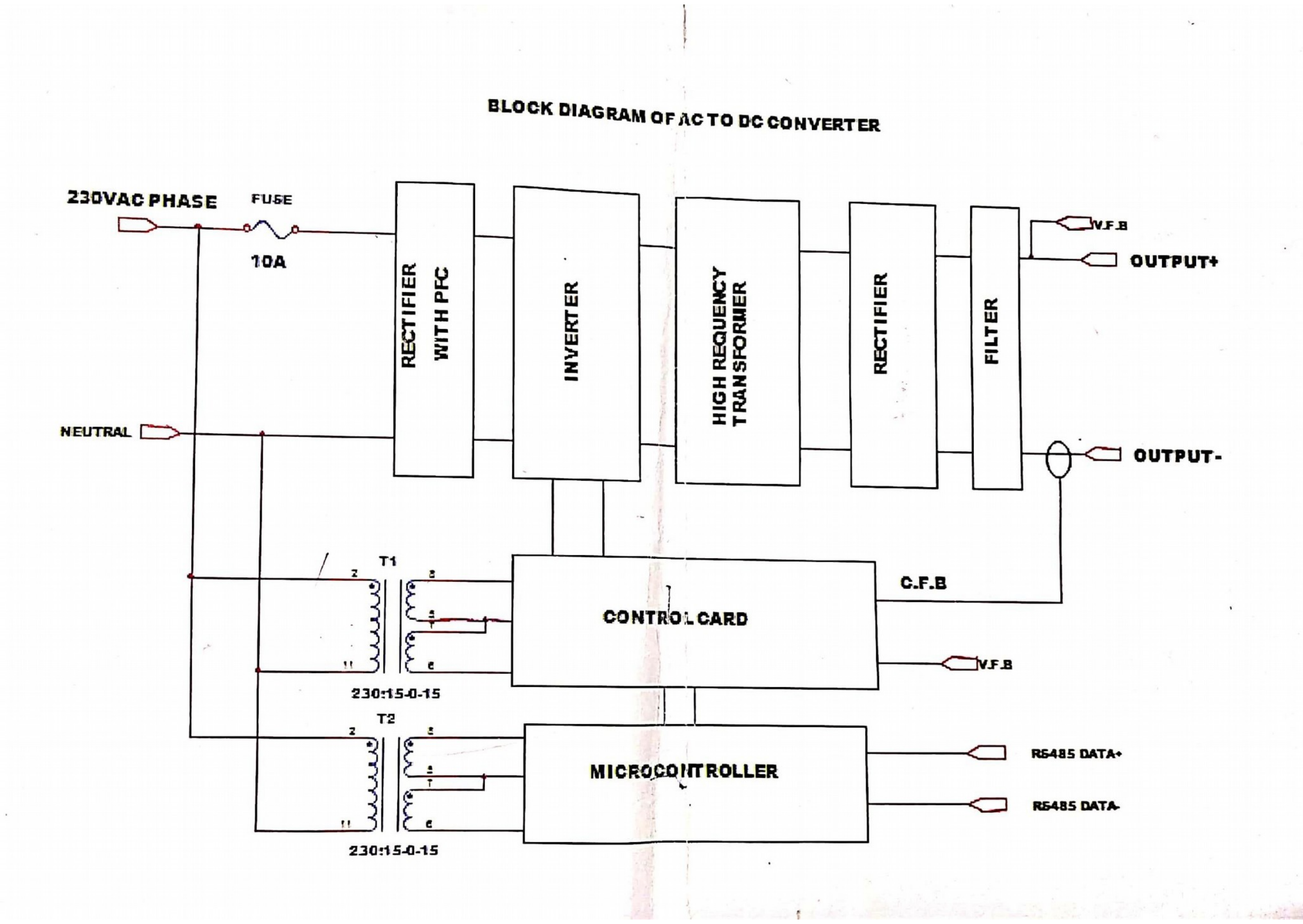


fig: Block diagram of Laser Diode Drivers

A Laser Diode Driver works with in two modes, as stated below:
1. Constant Current Source
2. Temperature Control

A 230V AC is converted to DC using a transformer and given to a Rectifier with PFC.

CAPACITORS : Capacitors are used for power factor correction. Power-factor correction increases the power factor of a load, improving efficiency for the distribution system to which it is attached.

INVERTER : Single-phase inverter to cope with the double-line frequency power pulsation in the inverter DC side. MOSFETS are used for for inverting.

HIGH FREQUENCY TRANSFORMER : High-frequency transformers operate using the same basic principles as standard transformers. The primary difference is that, as their name implies, they operate at much higher frequencies — while most line voltage transformers operate at 50 or 60 Hz, high-frequency transformers use frequencies from 20 KHz to over 1MHz. Operating at a higher frequency has many benefits, the first of which is size. For any given power rating, the higher the frequency, the smaller the transformer can be. Second, because the transformer is smaller, less copper wire is needed, thus reducing the losses and helping to make the transformer more efficient.

RECTIFIER : A rectifier comprised of one or more diodes which allow the flow of current only in one direction. It basically converts alternating current into direct current. A full wave rectifier is used to remove any stray frequencies and give only the desired range of frequency using a combination of diode and capacitor.

FILTER : **Electronic filters** are a type of signal processing filter in the form of electrical circuits consisting of discrete (lumped) electronic components. Such filters remove unwanted frequency components from the applied signal, enhance wanted ones, or both.
The filtered output is passed through a transformer to further step down the voltage and the output is given to a control card .

CONTROL CARD: An **Electronic Control Unit** (**ECU**) is any embedded system that controls one or more of the electrical systems.
The laser diode employs the following subunits in its control card :

1) OUTPUT OVER VOLTAGE PROTECTION: Voltage regulator ICs are used to regulate the voltage .
2) PULSE WIDTH MODULATION: UC2525 it used to modulate input dc voltage into timed pluses of required time and frequency .
3) CURRENT FEEDBACK : Current feedback refers to any closed-loop configuration in which the error signal used for feedback is in the form of a current. A current feedback op amp responds to an error current at one of its input terminals, rather than an error voltage, and produces a corresponding output voltage
4) VOLTAGE FEEDBACK : Voltage feedback, as the name implies, refers to a closed-loop configuration in which the error signal is in the form of a voltage. Traditional op amps use voltage feedback, that is, their inputs will respond to voltage changes and produce a corresponding output voltage.

MICROCONTROLLER : The voltage pulses from transformer 2 are sent to a microcontroller which is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip. The output of which is given to a data receiver.

TEC CONTROL

TEC controllers are used for thermoelectric cooling and heating in combination with Peltier elements or resistive heaters. Peltier elements are heat pumps which transfer heat from one side to the other, depending on the direction of the electrical current. TEC controllers are used to drive the Peltier elements.

Numerous technical and scientific applications require an object to be actively held at constant temperature, regardless of internal heat generation and external temperature fluctuations. Modern miniature temperature control equipment is based on one or several temperature sensors, a TEC controller and on an element capable of rapid heating and cooling. The smaller the solution, the tougher the requirements towards the TEC controller to ensure thermal stability.

The Thermoelectric Effect

A thermoelectric cooler, short TEC or Peltier element, can actively transport heat from one of its surfaces to another, thus heat or cool, depending on the direction and the magnitude of the electrical current flowing through it. This thermoelectric current is calculated and supplied by a TEC controller. Since our TEC controllers have bipolar output there is no need to change your setup mechanically to switch from heating to cooling and vice versa.

Temperature Acquisition and Closed-Loop Control

For a TEC controller being able to regulate the temperature of an object, it must know the actual and some recent temperatures. The precision of the temperature measurement system is crucial for the achievable stability. The TEC controller will compare the current object temperature to the target value and provide the thermoelectric element with the adequate amount of current.

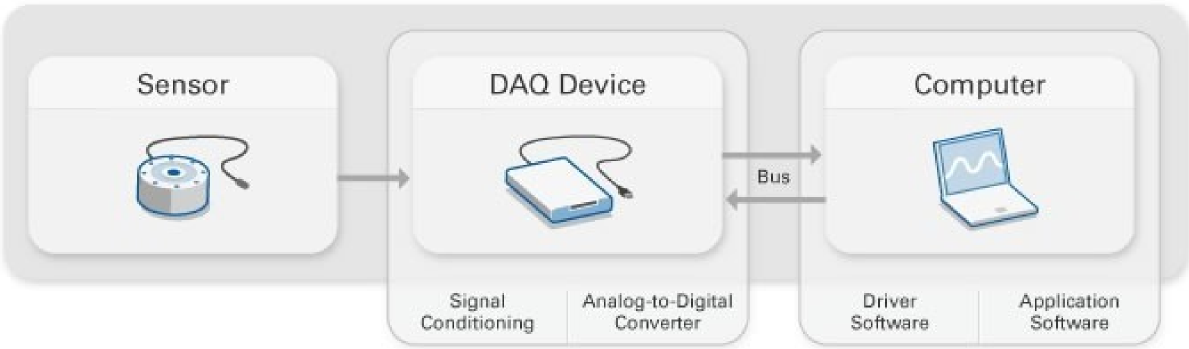
AIM 2
Development of DAC Application Software

DATA ACQUISITION

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound with a computer. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. Compared to traditional measurement systems, PC-based DAQ systems exploit the processing power, productivity, display, and connectivity capabilities of industry-standard computers providing a more powerful, flexible, and cost-effective measurement solution.

Components of a Data Acquisition System

All data acquisition systems consist of three essential elements – Sensor, Signal Conditioning, and Analog-to-Digital Converter (ADC).



DAQ Device

DAQ hardware acts as the interface between a computer and signals from the outside world. It primarily functions as a device that digitizes incoming analog signals so that a computer can interpret them. The three key components of a DAQ device used for measuring a signal are the signal conditioning circuitry, analog-to-digital converter (ADC), and computer bus. Many DAQ devices include other functions for automating measurement systems and processes. For example, digital-to-analog converters (DACs) output analog signals, digital I/O lines input and output digital signals, and counter/timers count and generate digital pulses.

Key Measurement Components of a DAQ Device

Signal Conditioning

Signals from sensors or the outside world can be noisy or too dangerous to measure directly. Signal conditioning circuitry manipulates a signal into a form that is suitable for input into an ADC. This circuitry can include amplification, attenuation, filtering, and isolation. Some DAQ devices include built-in signal conditioning designed for measuring specific types of sensors.

Analog-to-Digital Converter (ADC)

Analog signals from sensors must be converted into digital before they are manipulated by digital equipment such as a computer. An ADC is a chip that provides a digital representation of an analog signal at an instant in time. In practice, analog signals continuously vary over time and an ADC takes periodic “samples” of the signal at a predefined rate. These samples are transferred to a computer over a computer bus where the original signal is reconstructed from the samples in software.

Computer Bus

DAQ devices connect to a computer through a slot or port. The computer bus serves as the communication interface between the DAQ device and computer for passing instructions and measured data. DAQ devices are offered on the most common computer buses including USB, PCI, PCI Express, and Ethernet. More recently, DAQ devices have become available for 802.11 Wi-Fi for wireless communication. There are many types of buses, and each offers different advantages for different types of applications.

ABOUT THE SOFTWARE:

LABVIEW

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a system-design platform and development environment for a visual programming language from National Instruments.

The graphical language is named "G". Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of operating systems (OSs), including Microsoft Windows, various versions of Unix, Linux, and macOS.

The latest versions of LabVIEW are LabVIEW 2019 and LabVIEW NXG 3.1, released in May 2019.

Dataflow programming

The programming paradigm used in LabVIEW, sometimes called G, is based on data availability. If there is enough data available to a subVI or function, that subVI or function will execute. Execution flow is determined by the structure of a graphical block diagram (the LabVIEW-source code) on which the programmer connects different function-nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available. Since this might be the case for multiple nodes simultaneously, LabVIEW can execute inherently in parallel. Multi-processing and multi-threading hardware is exploited automatically by the built-in scheduler, which multiplexes multiple OS threads over the nodes ready for execution.

Graphical programming

LabVIEW integrates the creation of user interfaces (termed front panels) into the development cycle. LabVIEW programs-subroutines are termed virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector pane. The last is used to represent the VI in the block diagrams of other, calling VIs. The front panel is built using controls and indicators. Controls are inputs: they allow a user to supply information to the VI. Indicators are outputs: they indicate, or display, the results based on the inputs given to the VI. The back panel, which is a block diagram, contains the graphical source code. All of the objects placed on the front panel will appear on the back panel as terminals. The back panel also contains structures and functions which perform operations on controls and supply data to indicators. The structures and functions are found on the Functions palette and can be placed on the back panel. Collectively controls, indicators, structures, and functions are referred to as nodes. Nodes are connected to one another using wires, e.g., two controls and an indicator can be wired to the addition function so that the indicator displays the sum of the two controls. Thus a virtual instrument can be run as either a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the node through the connector pane. This implies each VI can be easily tested before being embedded as a subroutine into a larger program.

DAQNavi

DAQNavi is a completed software package, for programmers to develop their application programs using Advantech DAQ boards or devices. This integrated software package includes drivers, SDK, tutorial and utility. With the user-friendly design, even the beginner can quickly get familiar with how to utilize DAQ hardware and write programs through the intuitive "Advantech Navigator" utility environment. Many example codes for different development environment dramatically decrease users’ programming time and effort.

Supports multiple operating systems including Windows (32-bit and 64-bit), Linux

Supports common-used development environment including Visual C/C++, Borland C Builder, Visual Basic .NET, Visual C#, Delphi, Java, VB, LabVIEW

Supports Advantech PCI Express, PCI, PC/104, PCI-104, USB DAQ devices

Integrated utility environment (Advantech Navigator) for device functionality testing without programming

Able to generate a simulator device in utility to program and run application without real hardware device

Pre-defined scenario application examples with source code to shorten programming learning and development time

Express VI and Polymorphic VIs for both beginner and advanced programming in LabVIEW environment

Data Logger

A **data logger** (also **datalogger** or **data recorder**) is an electronic device that records data over time or in relation to location either with a built in instrument or sensor or via external instruments and sensors. Increasingly, but not entirely, they are based on a digital processor (or computer). They generally are small, battery powered, portable, and equipped with a microprocessor, internal memory for data storage, and sensors. Some data loggers interface with a personal computer, and use software to activate the data logger and view and analyze the collected data, while others have a local interface device (keypad, LCD) and can be used as a stand-alone device.

Data loggers vary between general purpose types for a range of measurement applications to very specific devices for measuring in one environment or application type only. It is common for general purpose types to be programmable; however, many remain as static machines with only a limited number or no changeable parameters. Electronic data loggers have replaced chart recorders in many applications.

One of the primary benefits of using data loggers is the ability to automatically collect data on a 24-hour basis. Upon activation, data loggers are typically deployed and left unattended to measure and record information for the duration of the monitoring period. This allows for a comprehensive, accurate picture of the environmental conditions being monitored, such as air temperature and relative humidity.

Operational Working of the DAC Software

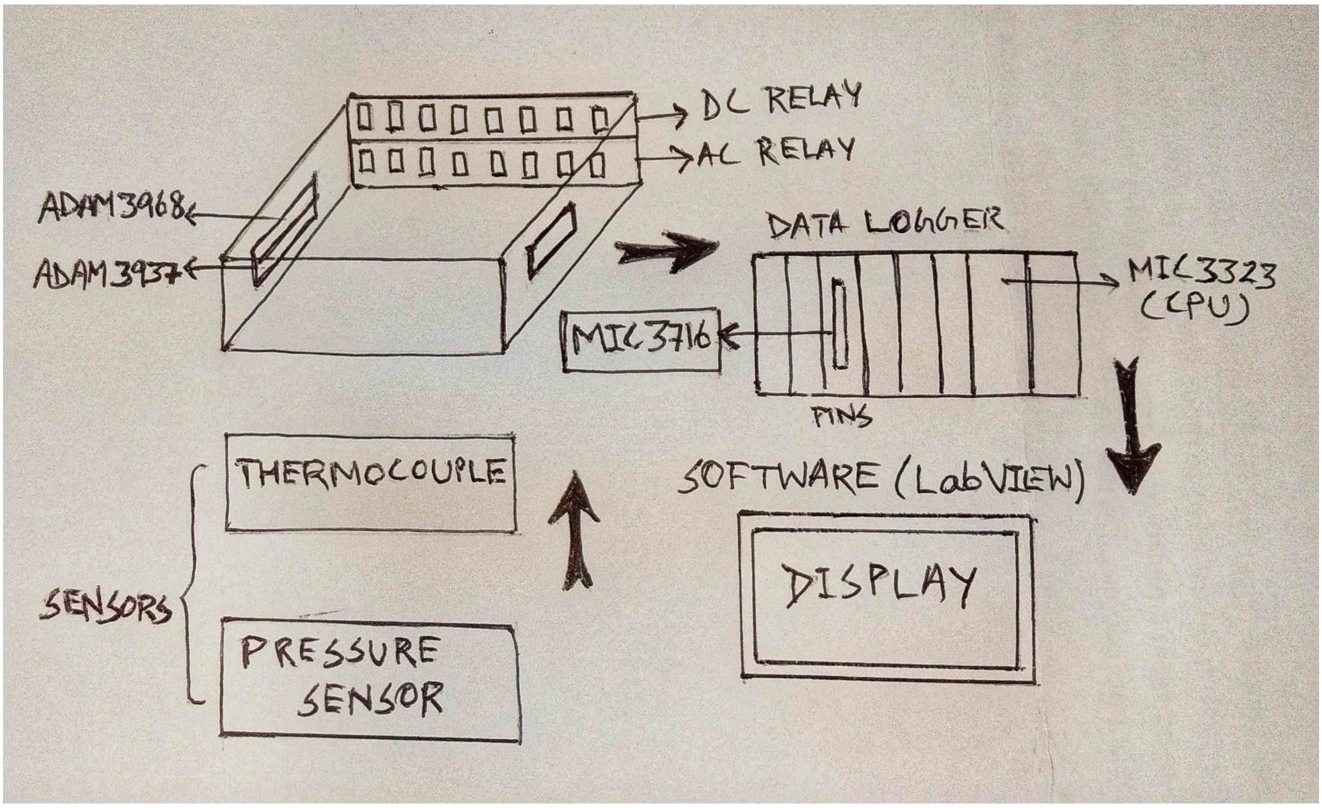


Fig.: Diagrammatic Representation of the working of the DAC System

The Components

MIC 3716

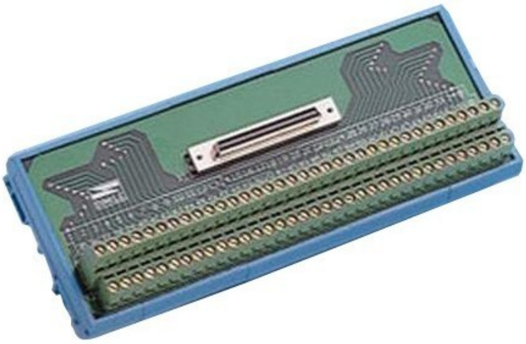
250 kS/s, 16-bit, 16-ch CPCI
Multifunction Card

- 16-bit high resolution
- 250 kS/s sampling rate
- Auto calibration function
- PCI-bus mastering for data transfer
- 16 analog input channels with 1K FIFO
- 16 S.E. or 8 Diff. AI, or a combination
- Unipolar/Bipolar input range
- 2 analog output channels
- 16 digital input channels
- 16 digital output channels

- One 10 MHz 16-bit resolution counter
- BoardID™ switch

The MIC-3716 is a powerful high-resolution multifunction card for PCI bus. It features a 250 KS/s 16-bit A/D converter, an on-board 1K sample FIFO buffer for A/D. The MIC-3716 provides a total of up to sixteen single-ended or eight differential A/D input channels or a mixed combination, two 16-bit D/A output channels, 16 digital input/output channels, and one 10 MHz 16-bit counter channel

ADAM 3968



68- pin DIN-rail SCSI Wiring Board

SCSI-II female connector

1. DIN-rail mounting terminal for industrial applications with 68-pin SCSI-II female connector
2. Case dimensions (W x L x H): 77.5 x 213.8 x 51 mm (3.1" x 8.4" x 2.0
3. Case dimensions (W x L x H): 77.5 x 191.2 x 51 mm (3.1" x 8.4" x 2.0")

Features:

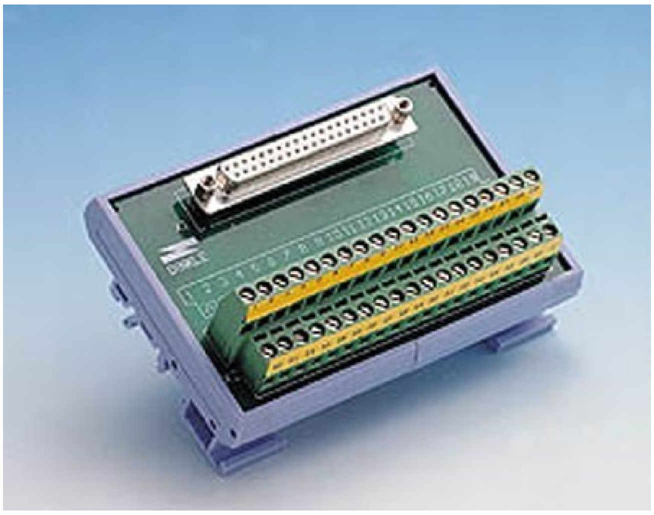
Low cost universal DIN-rail mounting screw terminal module for industrial applications with 68-pin SCSI female connector.

Case dimensions (W x L x H): 85.6 x 191.2 x 51 mm

To Be Used With

PCI-1710U/UL, PCI- 1710HGU, PCI-1711U/UL, PCI-1712/L, PCI -1716/L, PCI-1741U, PCI-1742U, PCI-1747U, PCI-
1721, PCI-1723, PCI-1751, PCI-1753, PCI-1723, PCI-1780U.

ADAM 3937



DB37 DIN-rail Wiring Board

Features:

Low cost universal DIN-rail mounting screw terminal module for DAQ cards with DB37 female connector

Case dimensions (W x L x H): 87.2 x 112.5 x 51 mm (3.4" x 4.4" x 2.0")

To Be Used With

PCI- 1713U, PCI-1715U, PCI-1718HDU, PCI-1720U, PCI-1730U, PCI-1733, PCI-1734, PCI-1750, PCI-1760U, PCI-176

Sensors

The measurement of a physical phenomenon, such as the temperature of a room, the intensity of a light source, or the force applied to an object, begins with a sensor. A sensor, also called a transducer, converts a physical phenomenon into a measurable electrical signal. Depending on the type of sensor, its electrical output can be a voltage, current, resistance, or another electrical attribute that varies over time. Some sensors may require additional components and circuitry to properly produce a signal that can accurately and safely be read by a DAQ device.

Common Sensors

Sensor	Phenomenon
Thermocouple, RTD, Thermistor	Temperature
Photo Sensor	Light
Microphone	Sound
Strain Gage, Piezoelectric Transducer	Force and Pressure
Potentiometer, LVDT, Optical Encoder	Position and
Displacement Accelerometer	Acceleration
pH Electrode	pH

Thermocouple

A thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature. Thermocouples are a widely used type of temperature sensor.

Commercial thermocouples are inexpensive, interchangeable, are supplied with standard connectors, and can measure a wide range of temperatures. In contrast to most other methods of temperature measurement, thermocouples are self powered and require no external form of excitation. The main limitation with thermocouples is precision; system errors of less than one degree Celsius (°C) can be difficult to achieve.Type E Thermocouple

Type E Thermocouple (Nickel-Chromium/Constantan): The Type E has a stronger signal & higher accuracy than the Type K or Type J at moderate temperature ranges of 1,000F and lower. The type E is also more stable than the type K, which adds to its accuracy.

Type E Temperature Range:

- Thermocouple grade wire, -454 to 1600F (-270 to 870C)
- 

- Extension wire, 32 to 392F (0 to 200C)

Type E Accuracy (whichever is greater):

- Standard: +/- 1.7C or +/- 0.5%
- Special Limits of Error: +/- 1.0C or 0.4%

Consideration for bare wire type E thermocouple applications:

- In oxiding or inert atmospheres the operating range is roughly –418F to 1,652F (–250C to 900C).

REOTEMP INSTRUMENTS

E

ITS-90 Table for Type E Thermocouple (Ref Junction 0°C)

http://reotemp.com

°C	0	1	2	3	4	5	6	7	8	9	10
	Thermoelectric Voltage in mV										
0	0.000	0.059	0.118	0.176	0.235	0.294	0.354	0.413	0.472	0.532	0.591
10	0.591	0.651	0.711	0.770	0.830	0.890	0.950	1.010	1.071	1.131	1.192
20	1.192	1.252	1.313	1.373	1.434	1.495	1.556	1.617	1.678	1.740	1.801
30	1.801	1.862	1.924	1.986	2.047	2.109	2.171	2.233	2.295	2.357	2.420
40	2.420	2.482	2.545	2.607	2.670	2.733	2.795	2.858	2.921	2.984	3.048
50	3.048	3.111	3.174	3.238	3.301	3.365	3.429	3.492	3.556	3.620	3.685
60	3.685	3.749	3.813	3.877	3.942	4.006	4.071	4.136	4.200	4.265	4.330
70	4.330	4.395	4.460	4.526	4.591	4.656	4.722	4.788	4.853	4.919	4.985
80	4.985	5.051	5.117	5.183	5.249	5.315	5.382	5.448	5.514	5.581	5.648
90	5.648	5.714	5.781	5.848	5.915	5.982	6.049	6.117	6.184	6.251	6.319
100	6.319	6.386	6.454	6.522	6.590	6.658	6.725	6.794	6.862	6.930	6.998
110	6.998	7.066	7.135	7.203	7.272	7.341	7.409	7.478	7.547	7.616	7.685
120	7.685	7.754	7.823	7.892	7.962	8.031	8.101	8.170	8.240	8.309	8.379
130	8.379	8.449	8.519	8.589	8.659	8.729	8.799	8.869	8.940	9.010	9.081
140	9.081	9.151	9.222	9.292	9.363	9.434	9.505	9.576	9.647	9.718	9.789
150	9.789	9.860	9.931	10.003	10.074	10.145	10.217	10.288	10.360	10.432	10.503
160	10.503	10.575	10.647	10.719	10.791	10.863	10.935	11.007	11.080	11.152	11.224
170	11.224	11.297	11.369	11.442	11.514	11.587	11.660	11.733	11.805	11.878	11.951
180	11.951	12.024	12.097	12.170	12.243	12.317	12.390	12.463	12.537	12.610	12.684
190	12.684	12.757	12.831	12.904	12.978	13.052	13.126	13.199	13.273	13.347	13.421
200	13.421	13.495	13.569	13.644	13.718	13.792	13.866	13.941	14.015	14.090	14.164
210	14.164	14.239	14.313	14.388	14.463	14.537	14.612	14.687	14.762	14.837	14.912
220	14.912	14.987	15.062	15.137	15.212	15.287	15.362	15.438	15.513	15.588	15.664
230	15.664	15.739	15.815	15.890	15.966	16.041	16.117	16.193	16.269	16.344	16.420
240	16.420	16.496	16.572	16.648	16.724	16.800	16.876	16.952	17.028	17.104	17.181
250	17.181	17.257	17.333	17.409	17.486	17.562	17.639	17.715	17.792	17.868	17.945
260	17.945	18.021	18.098	18.175	18.252	18.328	18.405	18.482	18.559	18.636	18.713
270	18.713	18.790	18.867	18.944	19.021	19.098	19.175	19.252	19.330	19.407	19.484
280	19.484	19.561	19.639	19.716	19.794	19.871	19.948	20.026	20.103	20.181	20.259
290	20.259	20.336	20.414	20.492	20.569	20.647	20.725	20.803	20.880	20.958	21.036
300	21.036	21.114	21.192	21.270	21.348	21.426	21.504	21.582	21.660	21.739	21.817
310	21.817	21.895	21.973	22.051	22.130	22.208	22.286	22.365	22.443	22.522	22.600
320	22.600	22.678	22.757	22.835	22.914	22.993	23.071	23.150	23.228	23.307	23.386
330	23.386	23.464	23.543	23.622	23.701	23.780	23.858	23.937	24.016	24.095	24.174
340	24.174	24.253	24.332	24.411	24.490	24.569	24.648	24.727	24.806	24.885	24.964
350	24.964	25.044	25.123	25.202	25.281	25.360	25.440	25.519	25.598	25.678	25.757
360	25.757	25.836	25.916	25.995	26.075	26.154	26.233	26.313	26.392	26.472	26.552
370	26.552	26.631	26.711	26.790	26.870	26.950	27.029	27.109	27.189	27.268	27.348
380	27.348	27.428	27.507	27.587	27.667	27.747	27.827	27.907	27.986	28.066	28.146
390	28.146	28.226	28.306	28.386	28.466	28.546	28.626	28.706	28.786	28.866	28.946
°C	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

E

The Pressure Sensor

Because of the great variety of conditions, ranges, and materials for which pressure must be measured, there are many different types of pressure sensor designs. Often pressure can be converted to some intermediate form, such as displacement. The sensor then converts this displacement into an electrical output such as voltage or current. The three most universal types of pressure transducers of this form are the strain gauge, variable capacitance, and piezoelectric.

Of all the pressure sensors, Wheatstone bridge (strain based) sensors are the most common, offering solutions that meet varying accuracy, size, ruggedness, and cost constraints. Bridge sensors are used for high and low pressure applications, and can measure absolute, gauge, or differential pressure. All bridge sensors make use of a strain gauge and a diaphragm.

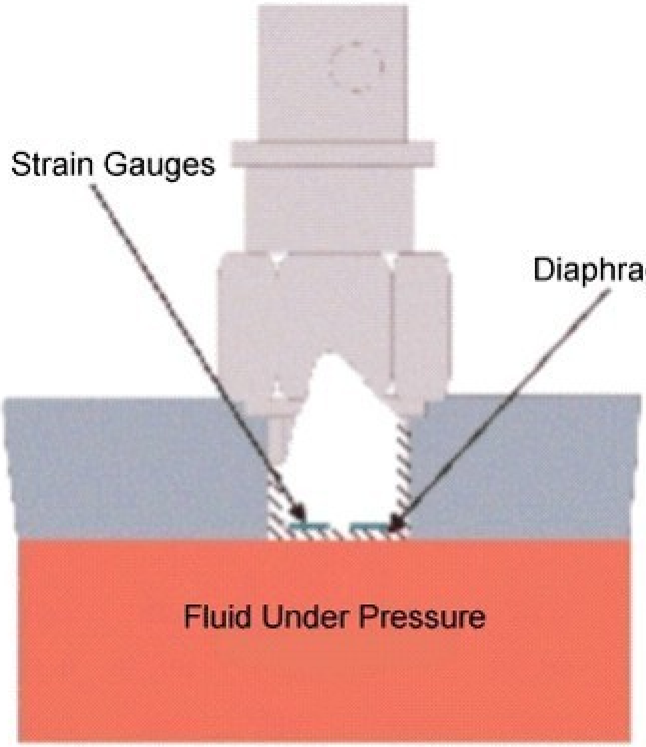


Figure: Cross Section of a Typical Strain Gauge Pressure Sensor

When a change in pressure causes the diaphragm to deflect, a corresponding change in resistance is induced on the strain gauge, which can be measured by a Data Acquisition (DAQ) System. These strain gauge pressure transducers come in several different varieties: the bonded strain gauge, the sputtered strain gauge, and the semiconductor strain gauge.

In the bonded strain gauge pressure sensor, a metal foil strain gauge is actually glued or bonded to the surface where strain is being measured. These bonded foil strain gauges (BFSG) have been the industry standard for years and are continually used because of their quick 1000 Hz response times to changes in pressure as well as their large operating temperature.

Sputtered strain gauge manufacturers sputter a layer of glass onto the diaphragm and then deposit a thin metal film strain gauge on to the transducer’s diaphragm. Sputtered strain gauge sensors actually form a molecular bond between the strain gauge element, the insulating layer, and the sensing diaphragm. These gauges are most suitable for long-term use and harsh measurement conditions.

Integrated circuit manufacturers have developed composite pressure sensors that are particularly easy to use. These devices commonly employ a semiconductor diaphragm onto which a semiconductor strain gauge and temperature-compensation sensor have been grown. Appropriate signal conditioning is included in integrated circuit form, providing a dc voltage or current linearly proportional to pressure over a specified range.

The capacitance between two metals plates changes if the distance between these two plates changes. A variable capacitance pressure transducer, measures the change in capacitance between a metal diaphragm and a fixed metal plate. These pressure transducers are generally very stable and linear, but are sensitive to high temperatures and are more complicated to setup than most pressure sensors.

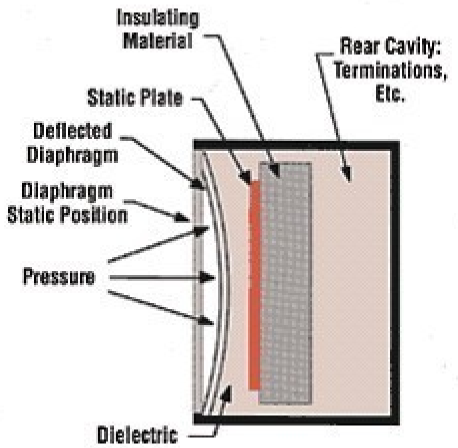


Figure: Capacitance Pressure Transducer

Piezoelectric pressure transducer take advantage of the electrical properties of naturally occurring crystals such as quartz. These crystals generate an electrical charge when they are strained. Piezoelectric pressure sensors do not require an external excitation source and are very rugged. The sensors however, do require charge amplification circuitry and very susceptible to shock and vibration.

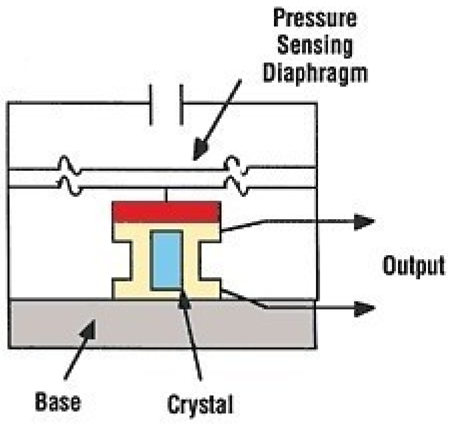


Figure: Piezoelectric Pressure Transducer

A common cause of sensor failure in pressure measurement applications is dynamic impact, which results in sensor overload. A classic example of overloading a pressure sensor is known as the water hammer phenomenon. This occurs when a fast moving fluid is suddenly stopped by the closing of a valve. The fluid has momentum that is suddenly arrested, which causes a minute stretching of the vessel in which the fluid is constrained. This stretching generates a pressure spike that can damage a pressure sensor. To reduce the effects of “water hammer”, sensors are often mounted with a *snubber* between the sensor and the pressure line. A snubber is usually a mesh filter or sintered material that allows pressurized fluid through but does not allow large volumes of fluid through and therefore prevents pressure spikes in the event of water hammer. A snubber is a good choice to protect your sensor in certain applications, but in many tests the peak impact pressure is the region of interest. In such a case you would want to select a pressure sensor that does not include over protection.

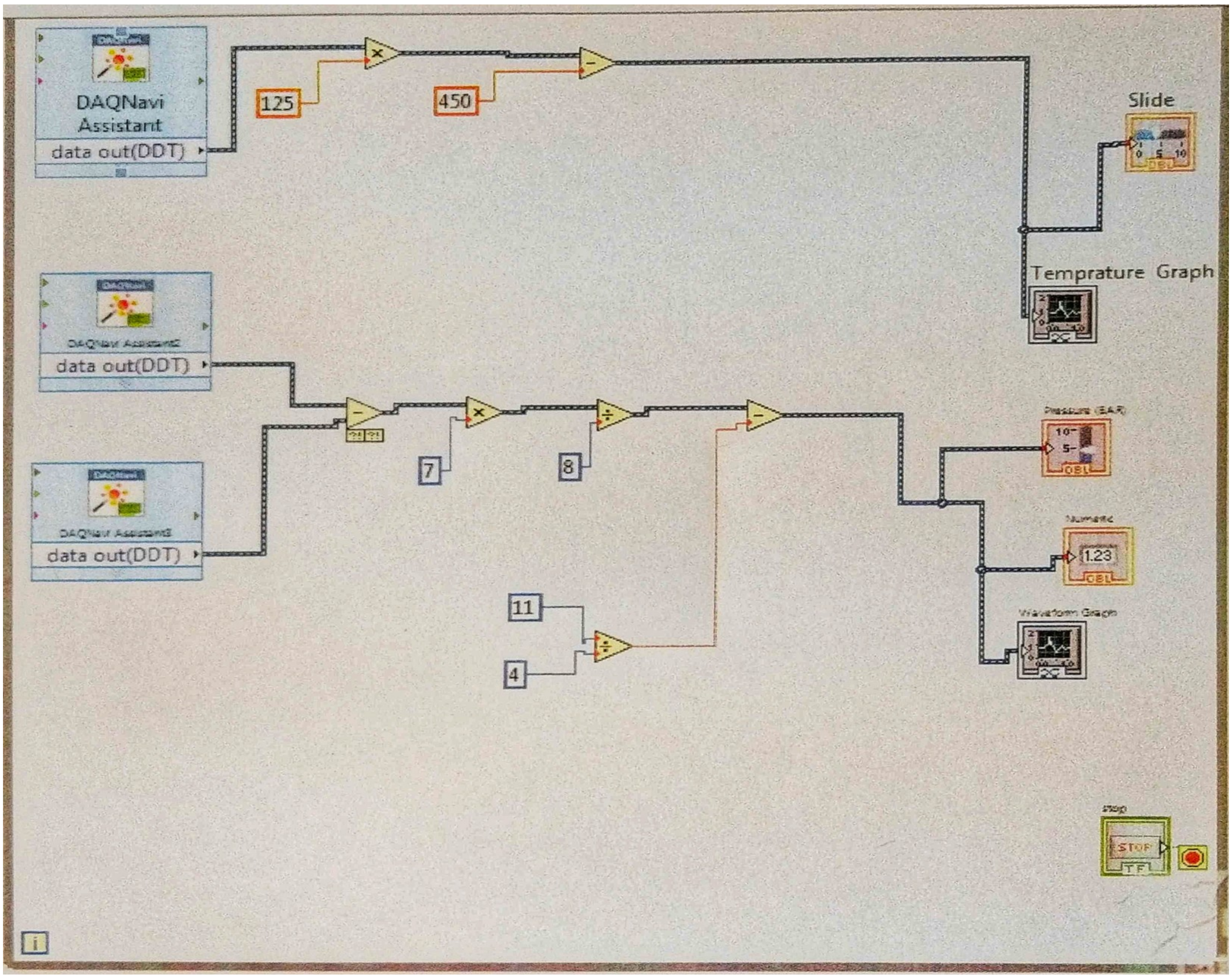


Figure: The program in LabVIEW using DAQNavi Assistant

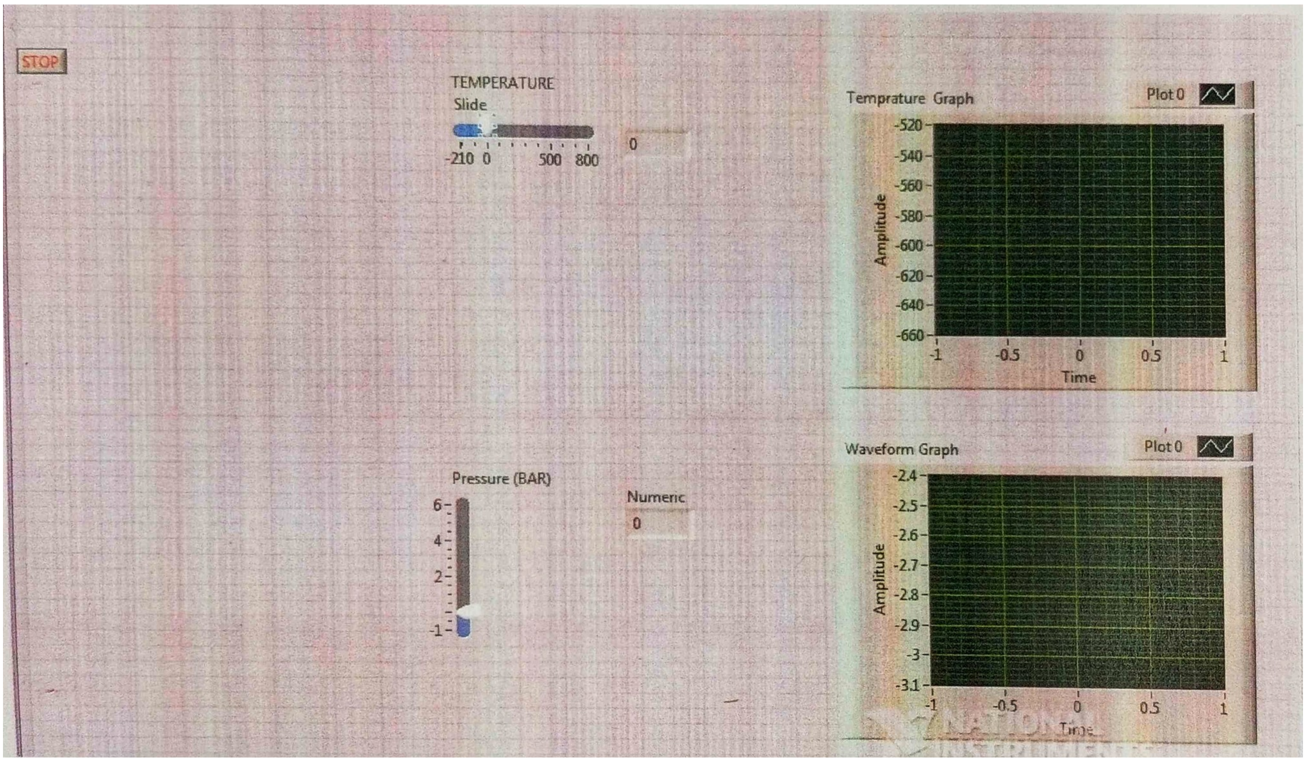


Figure: Graphical User Interface (GUI)

CONCLUSION

I) In the first experiment we have studied about the Laser Diode Drivers. We have studied the schematic of the LDD, including all the components, like the Power Card and the Control Card. We also did an extensive study on the working of Laser and it’s basic principles.

II) In the latter part of the project ,we have developed a DAC (Data Acquisition and Control) Software for the measurement of Temperature and Pressure from the respective sensors, i.e. thermocouple and pressure transmitter. The measurement of pressure and temperature presents a necessary condition for several industrial applications, mostly its precise regulation and/or maintaining it on a constant level means important challenge. The Type E thermocouples and diaphragm-type pressure sensors have eased the evolution of data acquisition systems used for temperature and pressure monitoring. The construction of such a system is presented in the project with temperature and pressure sensor, and the monitoring and control of the process is realized using LabVIEW. The reference values and the constants can be set through the panel of the virtual instrument and also here can be visualised its effects of the control on the process.