VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi-590018, Karnataka

AN INTERNSHIP REPORT

ON

"AUXILIARY GATE CONTROLLER MODULE FOR TRACTION"

Submitted in partial fulfilment of the requirements for the award of the degree

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

SUBMITTED BY

NAME: APOORVA M

USN:1DB20EC007

Internship work carried out at

BHARAT HEAVY ELECTRICALS LIMITED, ELECTRONICS DIVISION
BANGALORE – 560026

UNDER THE GUIDANCE OF

Internal guide	External guide
Prof. Suresha H S	**Shri. Venkatesh T**
Associate Professor	**Manager/SA-Testing**
Dept. of ECE, DBIT	BHEL

Department of Electronics and Communication Engineering

DON BOSCO INSTITUTE OF TECHNOLOGY

Kumbalagodu, Mysore road, Bangalore-74

2023-24

DON BOSCO INSTITUTE OF TECHNOLOGY

Kumbalagodu, Mysore Road, Bangalore-560074

Department of Electronics and Communication Engineering

CERTIFICATE

This is to certify that the Internship work entitled **"AUXILIARY GATE CONTROLLER MODULE FOR TRACTION"** carried out by **APOORVA M (1DB20EC007),** bonafide student of Don Bosco Institute of Technology in partial fulfilment for the award of Bachelor of Engineering in Electronics and Communication Engineering of the Visvesvaraya Technological University, Belagavi during the year 2023-2024. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated and the Internship report has been approved as it satisfies the academic requirements in respect of Internship work prescribed for the award of the degree of Bachelor of Engineering.

Signature of the Guide	Signature of the HOD	Signature of the Principal
Prof. Suresha H S	**Dr. Maheswarappa A N**	**Prof. B S Nagabhushana**
Associate Professor	Professor and HOD	Principal
Dept of ECE, DBIT	Dept of ECE, DBIT	DBIT

Name of the examiner	Signature of the Examiner
1) -----------------------	1) -----------------------
2) ----------------------	2) ---------------------------

बी एच ई एल
BHEL

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भारत हेवी इलेक्ट्रिकल्स लिमिटेड, इलेक्ट्रॉनिक्स डिवीज़न, बेंगलुरु-26
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Certificate

This is to certify that

Ms. APOORVA .M

A STUDENT OF B.E.

[ELECTRONICS AND COMMUNICATION ENGINEERING]

DON BOSCO INSTITUTE OF TECHNOLOGY

MYSORE ROAD, BENGALURU - 560 074.

were provided with facilities to do Internship at BHEL, ELECTRONICS DIVISION, BENGALURU as per following details :

" AUXILIARY GATE CONTROLLER MODULE FOR TRACTION "

UNDER THE GUIDANCE OF

SHRI VENKATESH .T
MANAGER / SA - TESTING

During of Internship (Offline)	04 Weeks	From	16.08.2023	To	13.09.2023

This permission to do the Internship was accorded as per request from the institution where the students are studying, for partial fulfillment of the completion of the course.

The Student showed keen interest in the training and has completed the Internship. Her Character and Conduct during the training period was found as 'EXCELLENT'.

19.09.2023

Signature of Issuing Authority
with Seal

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नवीन चन्द्र, वरि. उ.म.प्र.(मा.सं.-रा.भा. एवं मा.सं.वि.)
NAVIN CHANDRA, SR. DGM (HR-OL & HRD)
BHEL-EDN, MYSURU ROAD, BENGALURU-560026

Place : Bengaluru.
Date : 13.09.2023

DON BOSCO INSTITUTE OF TECHNOLOGY

Kumbalagodu, Mysore road, Bangalore-74

Department of Electronics and Communication Engineering

DECLARATION

I, **APOORVA M,** student of Electronics and Communication Engineering bearing the **USN:1DB20EC007**, hereby declare that I own the full responsibility for the information, results and conclusion provided in this report titled **"AUXILIARY GATE CONTROLLER MODULE FOR TRACTION".** Submitted to Visvesvaraya Technological University, Belagavi during the academic year 2023-2024.

To best of my knowledge, this internship work has been submitted in part or full elsewhere in any organization for the award of degree. I have completely taken care in acknowledging the contribution of the others in this academic work. I further declare that in case of any violation of intellectual property rights and particulars declared found at any stage. I will be responsible for the same.

Date: **APOORVA M**

Place: Bangalore **1DB20EC007**

ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of the people who made it possible and under whose constant guidance and encouragement the task was completed.

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I would like to express my sincere thanks to the internship coordinator **Mrs. Babitha S**, Assistant professor, Department of Electronics and Communication Engineering, DBIT, for her encouragement throughout the course.

I also extent my sincere thanks to my **Prof. Suresha H S,** Associate Professor and all the Faculty members of Department of Electronics and Communication Engineering, DBIT, Bangalore, who have encouraged me throughout the course.

My sincere gratitude to **Shri. Venkatesh T, Manager/SA-Testing** for accepting my internship request and allowing me to complete my internship and all the staff members for their kind help extended during the entire period of Internship.

I would like to thank **BHEL, ELECTRONICS DIVISION** for giving me the opportunity to complete my internship work.

Last but not least, I express my heartfelt gratitude to the almighty, my parents for their love and blessings that helped me complete the Internship work successfully.

Thanks and Regards
APOORVA M
1DB20EC007

ABSTRACT

This report presents a summary of the activities I was involved in during the internship at Bharat Heavy Electricals Limited (BHEL). The purpose of the internship was to study more about the traction and control system products. The company has supplied thousands of Electric Locomotives to Indian Railway. BHEL is an integrated power plant equipment manufacturer and one of the largest Engineering and manufacturing companies of its kind in India.

This internship was a perfect opportunity for me to learn about the control systems. Over learning about the traction and control system manufacturing, I was also able to enhance my communication skills, flexibility, etc. Finally, I would say this was a beautiful experience, from where we were able to know the things which are very important for our country and we were proud of it.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO BHEL

Bharat Heavy Electricals Limited (BHEL) owned and founded by the Government of India, is an engineering and manufacturing company based in New Delhi, India. Established in 1956, BHEL is India's largest power generation equipment manufacturer. BHEL was established in 1956 ushering in the indigenous Heavy Electrical Equipment industry in India.

Figure 1.1: BHEL-EDN

Heavy Electricals (India) Limited was merged with BHEL in 1974.In 1991 , BHEL was converted into a public limited company. Over time, it developed the capability to produce a variety of electrical, electronic and mechanical equipments for all sectors, including transmission, transportation, oil and gas and other allied industries. However, the bulk of the revenue of the company is derived from sale of equipment for power generation such as turbines, boilers, etc. As of 2017, BHEL supplied equipment contributed to about 55% of the total installed power generation capacity of India. The company has also supplied thousands of Electric Locomotives to Indian Railway, as well as defence equipment such as the Super Rapid Gun Mount (SRGM) naval guns manufactured in partnership with the Indian Ordnance Factories and Defence Simulators to the Indian Armed Forces.

BHEL is engaged in the design, engineering, manufacturing, construction, testing, commissioning and servicing of a wide range of products, systems and services for the core sectors of the economy, viz. power, transmission, industry, transportation, renewable energy, oil & gas, and defence.

1.2 AUTOMATION AND POWER ELECTRONIC SYSTEMS

- Unified Automation for Power Plants (Distributed Control Systems)
- (DCS) for Steam Turbines, Steam Generators and Balance of plant systems
- Gas Turbine Control Systems
- Hydro Power Plant Control Systems
- Excitation Systems
- Industrial Automation
- Sub-station Automation and Supervisory Control
- Data Acquisition Systems (SCADA)
- DC Drive Systems
- AC Drive Systems
- Power Supplies
- Static Starters
- Traction Drive Systems for locos and Electrical Multiple

1.3 SERVICES OFFERED

- Harmonic Measurement and Analysis
- System study for Reactive Power Compensation Erection and Commissioning by highly experienced team of Engineers
- A highly competent team to respond to Customers' emergency needs
- Total Solutions to Renovation and Modernization requirements
- Concept to Commissioning solutions for large size
- Solar Power Plants

BHEL is executing the world's largest ±800kV, 6000 MW UHVDC Multi Terminal North East-Agra transmission link on a turnkey basis together with ABB, including design, system engineering, supply, installation and commissioning for Power Grid Corporation of India Ltd. This dual Bi-Pole project consisting of Bi-Pole 1 and Bi-Pole 2 will enable the transmission of 6000MW power over the distance of 1728 Km from BiswanathChariali in Assam and Alipurduar in West Bengal to Agra in Uttar Pradesh. The link has a 33% overload capability, making it the world's largest multi-terminal ±800kV UHVDC project. This huge infrastructure will help in connecting the bulk remote generation in north east and eastern part of the country to the load centres in north of India. In addition to it, the link is also capable of bi-directional power flow. Pole 1 of the first phase of the Bi-pole 1 is running successfully under commercial operation since 1st November 2015.

BHEL products include air preheaters, boilers, control relay panels, electrostatic precipitators, fabric filters, fans, gas turbines, hydro power plant, piping systems, pumps, seamless steel tubes, soot blowers, steam generators, steam turbines, heat exchangers and many more.

- Bharat Heavy Electricals Limited (BHEL) has been ranked the Ninth Most Innovative Company in the world by the renowned US business magazine Forbes in 2011
- BHEL wins ICWAI National Awards for Excellence in Cost Management for the sixth consecutive year; maximum number of awards conferred on BHEL among public and private sector companies.
- BHEL's Innovativeness gets Global Recognition; Forbes ranks BHEL at No.9 in the list of the World's 100 Most Innovative Companies.
- BHEL gets Golden Peacock Award 2011 for Occupational Health and Safety.
- 2010– BHEL bags EEPC's Top Export Award for the 20th consecutive year.

BHEL wins MoU Excellence Award for the year 2006–07 for the highest growth rate in Market Capitalization. BHEL manufactures over 180 products under 30 major product groups and caters to core sectors of the Indian Economy viz., Power Generation & Transmission, Industry, Transportation, Telecommunication, Renewable Energy, etc. The wide network of BHEL's 15 manufacturing divisions, four Power Sector regional centres, over 100 project sites, eight service centres and 18 regional offices, enables the Company to promptly serve its customers and provide them with suitable products, systems and services — efficiently and at competitive prices.

The high level of quality & reliability of its products is due to the emphasis on design, engineering and manufacturing to international standards by acquiring and adapting some of the best technologies from leading companies in the world, together with technologies developed in its own R&D centres.

BHEL is one of the largest engineering and manufacturing companies of its kind in India engaged in design, engineering, construction, testing, commissioning and servicing of a wide range of products and services with over 180 product offerings to meet the evergrowing needs of the core sectors of economy.

CHAPTER 2

CIRCUIT DESIGN

2.1 PCB Designing

Printed circuit board (PCB) design brings your electronic circuits to life in the physical form. Using layout software, the PCB design process combines component placement and routing to define electrical connectivity on a manufactured circuit board.

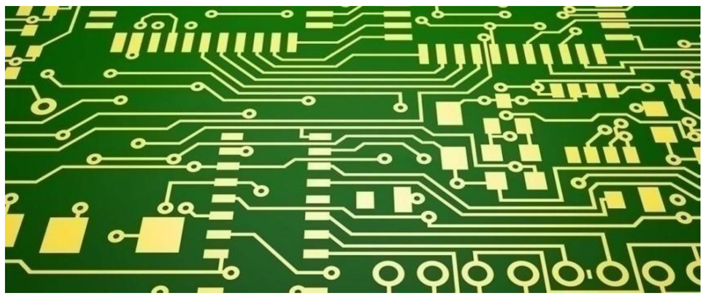


Figure 2.1: PCB Designing

Printed circuit boards (PCBs) are usually a flat laminated composite made from nonconductive substrate materials with layers of copper circuitry buried internally or on the external surfaces. They can be as simple as one or two layers of copper, or in high density applications they can have fifty layers or more.

Due to the solder mask, which protects the copper circuits printed on the fibre glass core to prevent short circuits, soldering errors , etc. The colour of the solder mask gives the board its appearance.

When it comes to PCB design, Extended Gerber is an excellent piece of software because it also works as an output format. Extended Gerber encodes all the information that the designer needs, such as the number of copper layers, the number of solder masks needed and the other pieces of component notation. Once a design blueprint for the PCB is encoded by the Gerber Extended software, all the different parts and aspects of the design are checked over to make sure that there are no errors.

Once the examination by the designer is complete, the finished PCB design is sent off to a PCB fabrication house so that the PCB can be built.

A printed circuit board can have multiple layers of copper which almost always are arranged in pairs. The number of layers and the interconnection designed between them provide a general estimate of the board complexity.

2.2 PCB Fabrication

Printed circuit board fabrication can be defined as a process of putting together the layers of the board along with particular surface patterns before making it fully usable for electronics manufacturing.

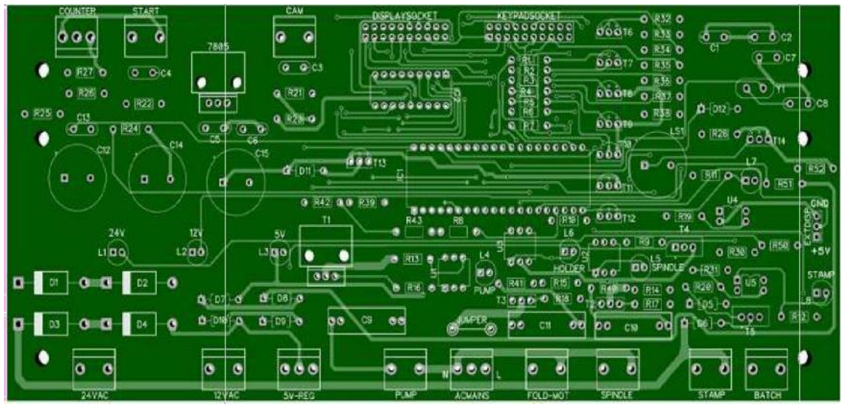


Figure 2.2: PCB Fabrication

Printed Circuit Board (PCB) fabrication is the process or procedure that transforms a circuit board design into a physical structure based upon the specifications provided in the design package. This physical manifestation is achieved through the following actions or techniques: Imaging desired layout on copper clad laminates.

Printed Circuit Boards (PCBs) form the backbone of all major electronics. These miraculous inventions pop up in nearly all computational electronics, including simpler devices like digital clocks, calculators etc. For the uninitiated, a PCB routes electrical signal through electronics, which satisfies the device's electrical and mechanical circuit requirements. In short, PCBs tell the electricity where to go, bringing your electronics to life.

PCBs direct current around their surface through a network of copper pathway . The complex system of copper routes determines the unique role of each piece of PCB circuit board.

As you can see, a lot of work goes into printed circuit board manufacturing process. To guarantee PCBs be manufactured with your expected quality, performance and durability, you have to pick a Manufacturer who has high level of expertise and a focus on quality at each stage.

PCBs require additional design effort to lay out the circuit, but manufacturing and assembly can be automated. Electronic design automation software is available to do much of the work of layout. Mass-producing circuits with PCBs is cheaper and faster than with other wiring methods, as components are mounted and wired in one operation

2.2.1 PCB Fabrication Process Steps

Step 1: Design and Output

Circuit boards should be rigorously compatible with, a PCB layout created by the designer using PCB design software. Commonly-used PCB design software includes Altium Designer, OrCAD, Pads, KiCad, Eagle etc.

Once the PCB design is approved for production, designers export the design into format their manufacturers support. The most frequently used program is called extended Gerber.

Step 2: From File to Film

PCB printing begins after designers output the PCB schematic files and manufacturers conduct a DFM check. Manufacturers use a special printer called a plotter, which makes photo films of the PCBs, to print circuit boards. Manufacturers will use the films to image the PCBs. Although it's a laser printer, it isn't a standard laser jet printer. Plotters use incredibly precise printing technology to provide a highly detailed film of the PCB design.

Step 3: Printing the Inner layers

The creation of films in previous step aims to map out a figure of copper path. Now it's time to print the figure on the film onto a copper foil.

This step in PCB manufacturing prepares to make actual PCB. The basic form of PCB comprises a laminate board whose core material is epoxy resin and glass fiber that are also called substrate material. Laminate serves as an ideal body for receiving the copper that structures the PCB. Substrate material provides a sturdy and dust-resistant starting point for the PCB. Copper is pre-bonded on both sides. The process involves whittling away the copper to reveal the design from the films.

Step 4: Layer Alignment and Optical Inspection

With all the layers clean and ready, the layers require alignment punches to ensure they all line up. The registration holes align the inner layers to the outer ones. The technician places the layers into a machine called the optical punch, which permits an exact correspondence so the registration holes are accurately punched.Once the layers are placed together, it's impossible to correct any errors occurring on the inner layers. Another machine performs an automatic optical inspection of the panels to confirm a total absence of defects.

The original design from Gerber, which the manufacturer received, serves as the model. The machine scans the layers using a laser sensor and proceeds to electronically compare the digital image with the original Gerber file.

Step 5: Layer-up and Bond

In this stage, the circuit board takes shape. All the separate layers await their union. With the layers ready and confirmed, they simply need to fuse together. Outer layers must join with the substrate. The process happens in two steps: layer-up and bonding.

The outer layer material consists of sheets of fiber glass, pre-impregnated with epoxy resin. The shorthand for this is called prepreg. A thin copper foil also covers the top and bottom of the original substrate, which contains the copper trace etchings. Now, it's time to sandwich them together.

The entire operation undergoes an automatic routine run by the bonding press computer. The computer orchestrates the process of heating up the stack, the point in which to apply pressure, and when to allow the stack to cool at a controlled rate.

Step 6: Solder Mask Application

Before the solder mask is applied to both sides of the board, the panels are cleaned and covered with an epoxy solder mask ink. The boards receive a blast of UV light, which passes through a solder mask photo film. The covered portions remain unhardened and will undergo removal.

Finally, the board passes into an oven to cure the solder mask.

Step 7: Surface Finish

To add extra solder-ability to the PCB, we chemically plate them with gold or silver. Some PCBs also receive hot air-leveled pads during this stage. The hot air leveling results in uniform pads. That process leads to the generation of surface finish. PCBCart can process multiple types of surface finish according to customers' specific demands.

Step 8: Profiling and V-Scoring

Now we've come to the last step: cutting, Different boards are cut from the original panel. The method employed either centers on using a router or a v-groove. A router leaves small tabs along the board edges while the v-groove cuts diagonal channels along both sides of the board. Both ways permit the boards to easily pop out from the panel. The final manufacturing stage is to profile the PCBs and cut them out of the production panel either by V-cut scoring or routing.

V-cut Scoring is a process of pre-separation of circuit boards. A 'V' shaped groove is cut at the top and bottom surface of an array of multiple repeats of the same printed circuit board or between a board and its rails by leaving a thin layer of separation between the 'Vs'.

A profile is a function of temperatures applied to the assembly over time.

2.3 PCB Assembly

The PCB assembly process is a simple one, consisting of several automated and manual steps. With each step of the process, a board manufacturer has both manual and automated options from which to choose.

2.3.1 Surface Mount Technology

Surface-mount technology (SMT) is a method in which the electrical components are mounted directly onto the surface of a printed circuit board(PCB). An electrical component mounted in this manner is referred to as a surface-mount device (SMD). In industry, this approach has largely replaced the through-hole technology construction method of fitting components, in large part because SMT allows for increased manufacturing automation which reduces cost and improves quality. It also allows for more components to fit on a given area of substrate. Both technologies can be used on the same board, with the through-hole technology often used for components not suitable for surface mounting such as large transformers and heat-sinked power semiconductors.

An SMT component is usually smaller than its through-hole counterpart because it has either smaller leads or no leads at all. It may have short pins or leads of various styles, flat contacts, a matrix of solder balls(BGA's), or terminations on the body of the component.

2.3.2 Surface Mount Technology (SMT) Screen Printers

Surface Mount Technology (SMT) screen printers are used to print solder paste on to a surface mount assembly forming the Printed Circuit Board (PCB) with the use of a metal mesh or stencils. It is a vital and initial part of the SMT process of every electronic device.

Figure 2.3.1: SMT Screen Printers

The SMT screen printers are broadly classified into three main sub-segments based on their technology: manual SMT screen printers, semi-automated SMT screen printers, and fully automated screen printers. Even though there is not as much of technology development in screen printers, there is high end-user demand from various industries such as consumer electronics, automotive, telecommunication, and so on, that has bolstered the growth of screen printers. An increasing number of customers are upgrading their shop floor with fully automated screen printers with advanced software platforms and faster cycle time to process. Electronic manufacturing services (EMS) providers are increasing the number of SMT equipment product lines in order to meet the growing demand from customers across different industry verticals, and this has bolstered the growth of screen printers. In addition, many original design manufacturers (ODMs) have also started manufacturing units, rather than just designing equipment, in order to overcome the increasing competition from EMS providers. This, in turn, has increased the demand for screen printers.

2.3.3 Pick and place machine

Pick and place robots are commonly used in modern manufacturing environments.

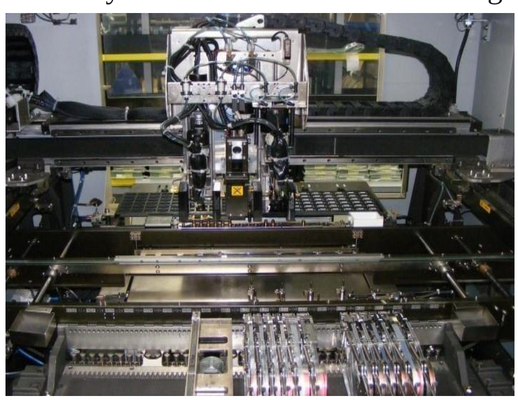


Figure 2.3.2: Pick and Place Machine

Pick and place automation speeds up the process of picking up parts or items and placing them in other locations. Automating this process helps to increase production rates.

2.3.4 Reflow ovens

Our SMT oven empowers developers, engineers, and product researchers everywhere with an advanced platform applicable within a variety of circuitry environments. Focused on uniform reflow soldering and software monitored forced air/nitrogen convection, our system allows for precision monitoring and development in several unique capacities. Typically, the reflow oven is part of an electronics assembly manufacturing line and is preceded by printing and placement machines.

Figure 2.3.3: Refllow Ovens Our

solder reflow oven is ideal for reflow soldering in:

- Prototype Environments
- Low – Medium Volume Environments

2.3.5 X – RAY Inspection

X-ray inspection technology, usually referred to Automated X-Ray inspection(AXI), is a technology used to inspect the hidden features of target objects or products with X-rays as its source.

Figure 2.3.4 : X-Ray Inspection

Nowadays, X-ray inspection is widely used in lots of applications such as medical, industrial control, and aerospace. As for PCB inspection, X-ray is massively used in the process of PCB assembly in order to test the quality of PCBs, which is one of the most important steps for quality-oriented PCB manufacturing. In x-ray images of PCBs, the metal is dark while other materials like glass, plastic and ceramics are transparent. This makes it easy to see metallic components.

2.3.6 Wave guide soldering

Automatic wave soldering machine is currently the mainstream of electronic products welding process.

Compared with other manual welding with a variety of manual has unparalleled advantages, and thus widely used by electronics manufacturers.

Figure 2.3.5: Wave Guide Soldering

The automatic claw wave soldering machine produced by our company is the most advanced using modern high-tech technology.

Wave soldering is an in-line process in which the underside of the printed circuit board is treated with flux, then preheated, and immersed in liquid solder. In the next step, the board is cooled. This is the gist of the entire wave soldering process. A machine is used to carry out this process. Here is a step-by-step explanation of the working of the wave soldering machine:

Step 1: Melting the Solder

This is the very first step in the entire wave soldering process. It is the basic requirement of the process to melt the solder. The wave soldering machine has solder contained in a tank. The tank is heated to melt the solder. Appropriate temperature is reached to meet the right consistency, so that the process of soldering can be carried out further.

Step 2 : Cleaning the Components

This is a very crucial step to be carried out. The components to be soldered are cleaning thoroughly in this step. If any oxide layers are formed on the components, then they are removed. This is done by the process called fluxing. There are two main types of fluxing – corrosive (high acidity) and noncorrosive (high acidity).

Step 3 : Placement of the PCB

After melting the solder and cleaning the components to be soldered, the printed circuit board is placed on the melted solder. The board is held with the metal clasps of the machine, which ensure the firm positioning and placement of the PCB.

Step 4 : Application of Solder

Now that the PCB is placed properly, molten solder is applied, and is allowed to settle. Sufficient time is given to this step to allow the solder to settle into the joints completely, and ensure no bumps are formed.

Step 5 : Cleaning

This is the final step in the wave soldering process. Any flux residues formed during the process are cleaned in this step. The circuit board is washed and cleaned with the help of deionized water and solvents.

Wave soldering is a bulk soldering process used for the manufacturing of printed circuit boards.

The circuit board is passed over a pan of molten solder in which a pump produces an upwelling of solder that looks like a standing wave.

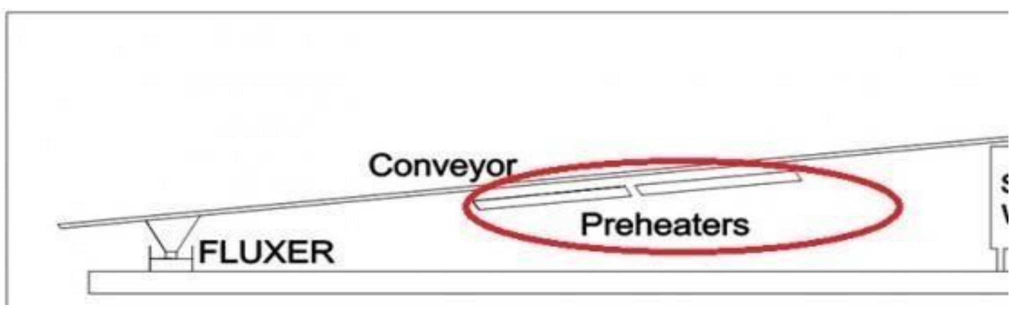


Figure 2.3.7: Wave Solder Machine Componenets

2.3.7 Fluxing

The flux method of crystal growth is a method where the components of the desired substance are dissolved in a solvent(flux).The method is particularly suitable for crystals needing to be free from thermal strain. It takes place in a crucible made of highly stable, non-reactive material. For production of oxide crystals, metals such as platinum, tantalum, and niobium are common. Production of metallic crystals generally uses crucibles made from ceramics such as alumina, zirconium and boron nitride. The crucibles and their contents are often isolated from the air for reaction, either by sealing them in a quartz ampoule or by using a furnace with atmosphere control. A saturated solution is prepared by keeping the constituents of the desired crystal and the flux at a temperature slightly above the saturation temperature long enough to form a complete solution. Then the crucible is cooled in order to allow the desired material to precipitate. Crystal formation can begin by spontaneous nucleation or may be encouraged by the use of a seed. As material precipitates out of the solution, the amount of solute in the flux decreases and the temperature at which the solution is saturated lowers. This process repeats itself as the furnace continues to cool until the solution reaches its melting point or the reaction is stopped artificially. In flux method synthesis, divergent crystal growth kinetics may emerge, with a small number of crystallites growing at the expense of neighbouring ones, resulting in abnormal grain growth.

2.3.8 Pre-Heating

The definition of preheating is the practice of applying heat to a PCB after flux deposition and immediately before soldering. Wave soldering can be performed without preheating, but the soldering speed will be slow. The age-old saying that "time is money" emphasizes the need for preheating. In the hand book of Machine Soldering SMT and TH, Woodgate mentions, "During some experimental work with preheating, a board was soldered at 12 ft. per minute with the normal preheat applied. Without preheat it could not be soldered faster than 2.5 ft. per minute." Just because a joint can be formed without this process doesn't mean that it should. The reasons given for preheating are almost always:

- To "activate" the flux by heating it.
- To prevent solder balls by drying the flux solvent that would otherwise spatter if only contacting the solder wave
- To reduce thermal shock to the PCB from the solder wave, thus decreasing warping and other defects associated with an abrupt increase in temperature.

The most important reason to use preheat is to "heat the board, components, terminations, and other parts of the joint so that the final heating and soldering can proceed more quickly." By minimizing the exposure to the molten solder, damage to the components can be minimized as well. Effects of preheating times (4, 8, and 12 min), preheating temperatures (75–210 °C, with 15 °C interval), and their interactions on structures and density profiles of sandwich compressed poplar wood were studied to achieve better control of the position(s) of compressed layer(s), with the aim of better utilization of the low-density wood resources.

2.3.9 Soldering Point

Metallised holes can be seen passing through the whole structure from top to bottom. These holes are then used as soldering bias that can guide the tin paste straight to the point where it is needed. When the paste is dried, soldered bias ensure a very good electrical contact between layers. Besides, the fluid tin fills any small gap that appears between layers, thus providing a very good electrical contact and mechanical union. This novel soldering technique has been validated with experimental results. Several prototypes of filters centered at 13 and 35 GHz have been fabricated, proving the repeatability and reliability of the proposed soldering technique.Selective Soldering is a process to solder individual through hole components on a PCB using a solder fountain. The machine includes a flux spray, preheater and a soldering pot that feeds a solder fountain. The solder fountain or head moves to the position to solder from underneath.

2.3.10 Selective Soldering

Selective soldering is the process of selectively soldering components to printed circuit boards and molded modules that could be damaged by the heat of a reflow oven or wave soldering in a traditional surface-mount technology (SMT) or through-hole technology assembly processes.

Figure 2.3.8: Selective Soldering

This usually follows an SMT oven reflow process; parts to be selectively soldered are usually surrounded by parts that have been previously soldered in a surface-mount reflow process, and the selective-solder process must be sufficiently precise to avoid damaging them. Selective soldering is a slower process than wave soldering; individual components are soldered sequentially by a local wave on an x-y gantry, as opposed to a full wave which hits all solder joints at once. However, further advantages have propelled selectivesoldering to become the preferred method in many cases.

2.3.11 Robotic Soldering

A Soldering Robot is a fully automated system that performs a designated task, set by a custom program, with the utmost precision and repeatability.

Figure 2.3.9: Robotic soldering

Each joint may have its own soldering profile. Base robots use our 150 watt power supply with a superior thermal feedback system. Nitrogen systems and vision alignment may also be added for the most challenging solder applications.

2.3.12 Conformal Coating

Conformal coating material is a thin polymeric film which conforms to the contours of a printed circuit board to protect the board's components.

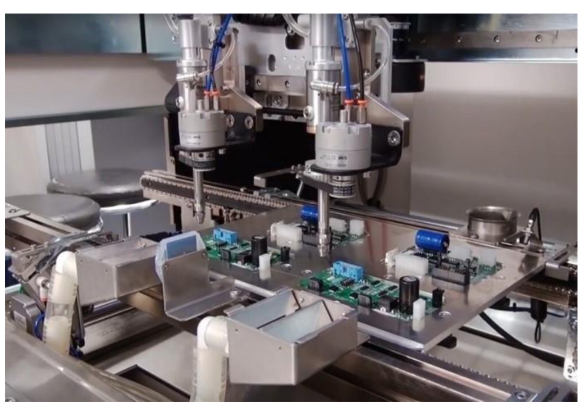


Figure 2.3.10: Conformal Coating

Typically applied at 25-250 μm it is applied to electronic circuitry to protect against moisture, dust, chemicals, and temperature extremes. Coatings can be applied in a number of ways, including brushing, spraying, dispensing and dip coating. Furthermore, a number of materials can be used as a conformal coating, such as acrylics, silicones, urethanes and paraethylene. Each has their own characteristics, making them preferred for certain environments and manufacturing scenarios. Most circuit board assembly firms coat assemblies with a layer of transparent conformal coating, which is lighter and easier to inspect than potting. Conformal coatings are breathable, allowing trapped moisture in electronic boards to escape while maintaining protection from contamination. These coatings are not sealants, and prolonged exposure to vapors will cause transmission and degradation to occur. There are typically four classes of conformal coatings: Acrylic, Urethane, Silicone, and Varnish. While each has its own specific physical and chemical properties each are able to perform the following functions:

- Insulation: Allowing closer conductor spacing.
- Eliminate the need for complex enclosures.
- Minimal effect on component weight.
- Completely protect the assembly against chemical and corrosive attack.
- Eliminate performance degradation due to environmental hazard.

2.3.13 PCB Testing

PCB testing, or printed circuit board testing, begins with understanding that the PCB is the foundation for any printed circuit assembly (PCA).

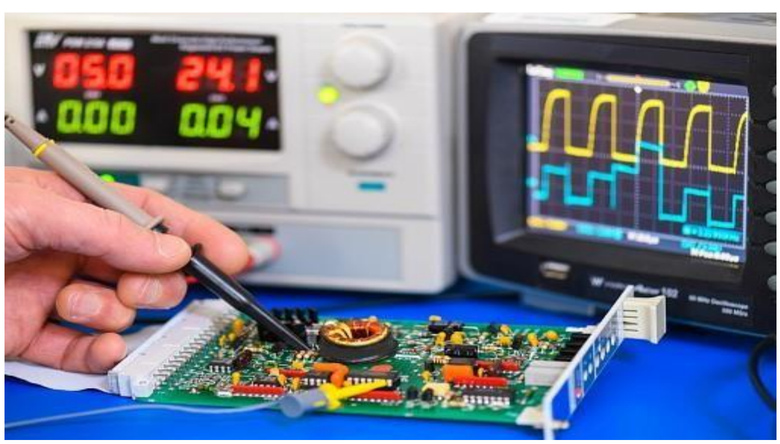


Figure 2.3.11 PCB Testing

The circuit board is a top quality product that should not cause your end product to cost you money due to failures and recalls.

PCB assembly testing methods are an integral part of the manufacturing process. Reputable electronics contract manufacturers (ECMs) offer a variety of PCB testing methods, but the seven main types include:

1. In-circuit testing.
2. Flying probe testing.
3. Automated optical inspection (AOI).
4. Burn-in testing.
5. X-Ray inspection.
6. Functional testing.
7. Other functional testing (solderability, contamination, and more).

If the components look fine, you'll need to power up the circuit board. Measure the voltage of the power rails with the multimeter. Both the input and output of the voltage regulator need to show the expected values.

The Input/Output are also common points of failure. Damage on I/O ports seldom shuts down the whole circuit, but it usually results in anomalies in the system. For example, an alarm controller that always senses an open door even if it's closed or a motor that is continuously activated.

Circuit board testing is a tedious process, particularly for issues like short circuits. However, there are ways you can optimize a PCB for future troubleshooting. For a start, you can create testing pads for voltages and critical signals like communications. It spares you from trying not to mistakenly short the neighboring trace with the multimeter probe.

As a final precaution, a technician performs electrical tests on the PCB. The automated procedure confirms the functionality of the PCB and its conformity to the original design.

CHAPTER 3
SEMICONDUCTORS

3.1 Semiconductor Assembly and Testing

Semiconductor Assembly and Test Services are converting rapidly into a pure outsourcing mode of operation. While today perhaps only 50% of the market is using Outsourced Semiconductor Assembly and Test (OSAT, or SATS) this number is set to increase in the future.

3.1.1 Lapping

Lapping is a machining process performed on a metal, ceramic or glass surface, to minimize its roughness. The exact definition given by dictionaries:" Lapping is a machining process, in which two surfaces are rubbed together with an abrasive between them, by hand movement or by way of a machine.

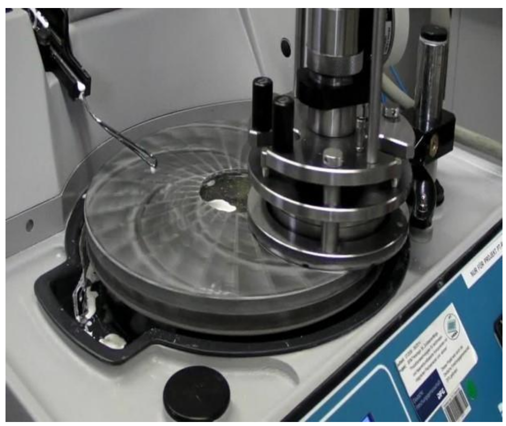


Figure 3.1: Lapping

The first type of lapping , usually called grinding, involves rubbing a brittle material such as glass against a surface such as iron or glass itself, known as the grinding tool, with an abrasive such as aluminium oxide, jeweller's rouge, optician's rouge, emery, silicon carbide, diamond, etc., between them. This produces microscopic conchoidal fractures as the abrasive rolls about between the two surfaces and removes material from both.

If you're looking for a semiconductor compound to silicon for manufacturing linear and digital integrated circuits, you should take a closer look at gallium arsenide (GaAs). However, if you want significant cost savings while maximizing the life of your wafers, GaAs reclaim wafers are your best bet. Wafer reclaim refers to used wafers that are reprocessed for different uses.

3.1.2 Annealing

Annealing is a heat treatment process which alters the microstructure of a material to change its mechanical or electrical properties. Typically, in steels, annealing is used to reduce hardness, increase ductility and help eliminate internal stresses.

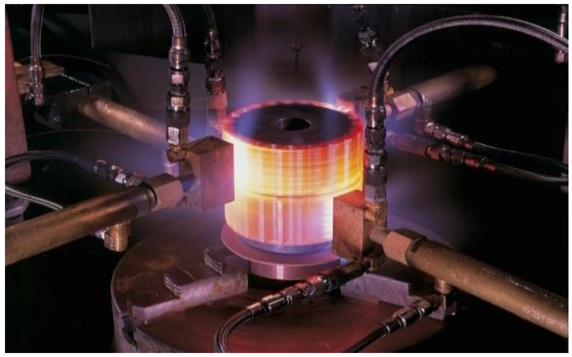


Figure 3.2: Annealing

In the case of ferrous metals, such as steel, annealing is performed by heating the material (generally until glowing) for a while and then slowly letting it cool to room temperature in still air. Copper, silver and brass can be either cooled slowly in air, or quickly by quenching in water.

3.1.3 Testing

Semiconductor test equipment (IC tester), or automated test equipment (ATE), is a system for giving electrical signals to a semiconductor device to compare output signals against expected values for the purpose of testing if the device works as specified in its design specifications.

3.1.4 Forward Voltage Drop Testing

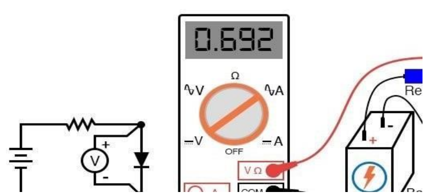


Figure 3.3: Forward Voltage Drop Testing

To measure the forward voltage, set the multimeters to their proper settings (ie. current and voltage). Always set the resistance to the highest value before testing it to avoid frying the LED. It may be easier to clamp the multimeter leads by inserting solid core wires to the breadboard. Lower the resistance until the current is up to 20 mA and record the voltage and current.

3.1.5 Blocking voltage Stability Test

Voltage stability assessment is a major issue in monitoring the power system stability. Different voltage stability indices (VSIs) have been proposed in the literature for voltage stability assessment.

Figure 3.4: Blocking Voltage Stability Test

The voltage stability assessment indicator is used to evaluate whether the voltage of a load node in the system is stable or not, so it is called indicator L.

These indices can be used for distributed generation (DG) placement and sizing, detecting the weak lines and buses and triggering the countermeasures against voltage instability. “Test Systems for Voltage Stability Analysis and Security Assessment” under the auspices of the Power System Stability Sub committee of the Power System Dynamic Performance Committee. These systems are based on previous test systems, making them more representative of voltage stability constraints. A set of representative results are provided for both systems, with emphasis on dynamic simulation. They illustrate various aspects such as long-term dynamics, voltage security assessment, real-time detection, and corrective control of instabilities. The value for educators, researchers and practitioners are emphasized.

Voltage stability covers a wide range of phenomena in power systems. In this chapter, voltage stability problems of distributed generators (DGs) are briefly described. Then, a new voltage-stability-analysis method for DGs connected to a weak power system is explained.

Voltage stability refers to the ability of a power system to maintain steady voltage at all buses in the system after being subjected to a disturbance from a given initial operating condition.

3.2 Element Fabrication

The outstanding feature of an IC is that is comprises an number of circuit elements inseparably associated in a single small package to perform a complete electronic circuit. We shall now see how various circuit elements (such as transistors, diodes, resistors etc.) can be fabricated in an IC form.

3.2.1 The Alloying Process

To create an alloy, the metals (or a metal and a nonmetallic element) are heated until they are molten. The two elements are mixed and the solution is poured into metal or sand molds to solidify. The resulting alloy is a combination of the two elements.

3.2.2 Bevelling Process

Bevelling is the process of creating an angled sloped edge on a piece of metal. This is formed in preparation for a welding seam and its uses are endless, ranging from minor steel projects such as cabinet creation to major civil infrastructure projects.

3.2.3 Metallization Process

Metallization is the process by which the components of IC's are interconnected by aluminium conductor. This process produces a thin-film metal layer that will serve as the required conductor pattern for the interconnection of the various components on the chip.

3.2.4 Etching

Etching in Fabrication Process. During IC fabrication, the whole wafer is completely covered with a layer or multi- layers of silicon dioxide, silicon nitride, or metal. Etching is the process of removing unwanted parts of these layers in order to form holes for diffusion, electrical interconnections and so on.

CHAPTER 4

LOCOMOTIVES

4.1 Propulsion System in Locomotives

Figure 4.1: BHEL Manufactured Train

Railway power equipment can broadly be classified depending on the source of energy:

- Steam, particularly, steam from water.
- Mineral oil products, particularly diesel fuel.
- Electricity.
- Combinations of different sources of energy.

Special cases, such as caustic soda locomotives, steam engines, gas engine railways, cable railways with fixed drive-systems, magnetic levitation railways or experimental procedures should not be considered further in this section.

The main 3 products are

- Traction converter
- Auxiliary converter
- Vehicle control unit
-

4.1.1 Traction Converter

Traction Converter would have multiple line converters which convert single phase AC input to a stable DC link bus voltage. A combination of one or more inverters converts this DC bus voltage to 3-phase power controlling one or more traction motors each. Traction converters also controls the slip-slide action of the wheels, harmonic correction in line side. Traction converter consists of Line side converter, DC Link and Series

Resonance Capacitors, Inverters, ferried cores,and Power Electronics cards (responsible for IGBT firing, monitoring and controlling of firing pulse).

Control Panel is used for controlling and protection of VCB, Auxiliary Converter, Traction Converter and other related accessories inside the Locomotive.

IGBT power module (water cooled).

Traction converter contains total 18 IGBT modules which consists of two panels namely TCA in which it contains 9 IGBT modules and TCB in which it contains 9 IGBT modules.

4.1.2 Auxiliary Converter

Auxiliary converters and drives are an integral part of the main traction drives. Auxiliary converters provides cooling of main drives, traction motors, diesel engine, charging the vehicle's batteries and feeding of control circuits in entire locomotive.

Figure 4.2: Auxiliary converter

Auxiliary converters convert single phase power from Locomotive step-down Transformer to three phases 50Hz power to supply to all the auxiliary loads of an Electric locomotive. Auxiliary converters form part of the auxiliary drive system in an ac locomotive which is primarily used to supply power to the auxiliary loads of an electric locomotive. Auxiliary loads include oil circulating pumps, oil cooling radiator blower, air compressors, motors to operate pantographs, transformer cooling pumps, traction motor cooling pumps, etc. It is typically of IGBT configuration that is fed from the auxiliary windings of the locomotive transformer. Auxiliary converters and drives are an integral part of the main traction drives.

Auxiliary converters provide cooling of main drives, traction motors, diesel engine, charging the vehicle's batteries and feeding of control circuits in entire locomotive.

4.1.3 Vehicle Control Unit

Vehicle Control Unit (VCU) is a very critical subsystem of the propulsion system, as it controls the complete characteristics and safety of the locomotive. VCU is based on the open control architecture and compliant to IEC-61375 "Train Communication Network" Protocol. The VCU can be adapted for any type of locomotive.

There are two VCU racks in locomotive VCU1 & VCU2, together performing all the functions. There are two processors in each rack. Both the processors can independently access all the analog and digital I/Os. The functions are divided between the four processors in such a way that any single processor failure will not affect functioning of locomotive.

VCU serves as the command and control center. Its primary functions are to analyze transducers' data and provide orders to executors or actuators to complete each action. The Vehicle Control Unit (VCU) plays a key role in the management and control of rail vehicles. Hasler Rail offers a complete range of on-board devices for a variety of applications.

The important parts of the locomotives are as follows:

- TM-traction motor
- CON-Converters
- Aux-Auxiliaries
- DCU-Drive Control Unit

The word locomotive originates from the Latin loco – "from a place", ablative of locus "place", and the Medieval Latin motivus, "causing motion", and is a shortened form of the term locomotive engine, which was first used in 1814 to distinguish between selfpropelled and stationary steam engines.

As “engine” is a synonym for “locomotive,” a diesel engine in a locomotive is often referred to as the “prime mover.” This eliminates the ambiguity between “engine” and “locomotive” and differentiates the main engine from any auxiliary ones, such as those used to produce head-end power on some passenger unit.’

Redundancy: Even if one processor fails the other one will take care of the functionalities. Any single processor failure will not lead into CAB failure and any single VCU failure will not lead into complete loco failure.

Anyway, the reason for using two locomotives is pretty simple. Twice the number of locomotives means twice the power. This extra power boost is used for especially heavy loads or for trains going up steep grades.

4.1.4 IGBT In Propulsion System

Insulated Gate Bipolar Transistors (IGBTs) are today's state-of-the-art power electronics for the traction system of electric (and diesel-electric) rail vehicles. They replace the previous inverter generation represented by GTO (gate turn-off thyristors).

Figure 4.3: IGBT in Propulsion System

An IGBT power module functions as a switch and can be used to switch electrical power on and off extremely fast and with high energy efficiency. The IGBT power module is becoming the preferred device for high power applications due to its ability to enhance switching, temperature, weight and cost performance.

An IGBT power module functions as an electronic switching device allowing the current to switch from DC to AC. By alternate switching direct current (DC) can be transformed to alternating current (AC) and vice-versa.

This power conversion is important for the applications to function correctly. For example, in order to drive an electrical motor, 3 phase AC current is needed. While on the other end, all electrical energy storage systems (batteries) need DC current. IGBT modules play an integral role in making this happen.

An AC-to-DC converter furnishing a regulated DC-output voltage from an AC-input supply voltage which is converted with a rectifier that utilizes, in at least two of its legs, IGBT (insulated gate bipolar transistor) devices, preferably of the kind that have no internal diodes.

IGBT modules handle kilowatts of power.

GTOs are power devices, and are mostly used in alternating current applications. IGBT is a semiconductor device with three terminals known as 'Emitter', 'Collector' and 'Gate'. It is a type of transistor which can handle a higher amount of power and has a higher switching speed making it high efficient.

CHAPTER 5
POWER PLANT

5.1 Thermal Power Plant.

A thermal power station is known as power plant in which the prime mover is steam drive. Water is made to enter into the system and then heated, later which turns into the steam. The steam spins in a steam turbine which efforts an electrical generator.

Figure 5.1: Thermal Power Plant

The Basic Components of The Thermal Power Station Are

- Boiler
- Steam turbine
- Generator
- Condenser
- Cooling towers
- Circulating water pump
- Boiler feed pump
- Forced or induced draught fans
- Ash precipitators

Water is used as the working fluid in the thermal power plant. We can see coal based and nuclear power plants in this category. From the working of the power plant energy, later from the fuel gets transferred into the form of electricity. With the help of high pressure and high steams a steam turbine in a thermal power plant is rotates, the rotation must be transfer to the generator to produce power.

When turbine blades are rotated with the high pressure and high temperature at that case the steam loses its energy. So, it results in the low pressure and low temperature at the outlet of the turbine. Steam must be expanded up to the point where it reaches the saturation point. So, from the steam, there is no heat addition or removal that takes place. Entropy of the steam remains same. So, we can notice the change in the pressure and volume and temperature along
with the entropy diagrams. If the condition comes to the low pressure and low temperature steam back to the original state, from that we can produce continuous electricity.

To compress the gaseous state liquids at that case large amount of energy is required. So before the compression we need to convert the fluids into liquid state. For this purpose condenser is required and heat is rejected to the surroundings and converts the steam into liquid state. During this process the temperature and volume of the fluid changes take place hardly, so it turns into liquid state. And the fluid turns to the original state. To bring the fluid to the original state external heat is added. To the heat exchanger heat is added which is called as boiler. Then the pressure of the fluid must remain same. In heat exchanger tubes it expands freely. Due to increase in temperature the liquid state is transformed into the vapour state and the temperature remains same. So know we complete the thermodynamic cycle in the thermal power plant. It is known as Rankine cycle. By repeating the cycle, we can produce the power continuously.

With the help of boiler furnace heat is added to the boiler. Then the fuel must reacts with the air and produces heat. The fuel must be either nuclear or coal. In this process if we use coal as a fuel, we can observe lot of pollutants before ejects in to the air clean or removed the particles and send into surroundings. The process is done in various steps. By using the electro static precipitator the ash particles are removed. So, with the help of the stack clean exhaust must be send outside.

CHAPTER 6

Insulated Gate Bipolar Transistor (IGBT)

The IGBT stands for an insulated gate bipolar transistor is three-terminal semiconductor components that operate as a switch. It provides both high efficiency and high-speed switching. In this module, there are 4 layers PNPN which is regulated through the metal oxide semiconductor gate structure with the absence of the regenerative process. IGBT is a new invented power electronic component before the creation of this module MOSFET and power Bipolar junction transistor were commonly used.

The **IGBT** (Insulated Gate Bipolar transistor) which provides conduction characteristics like bipolar junction transistor and voltage control like the MOSFET

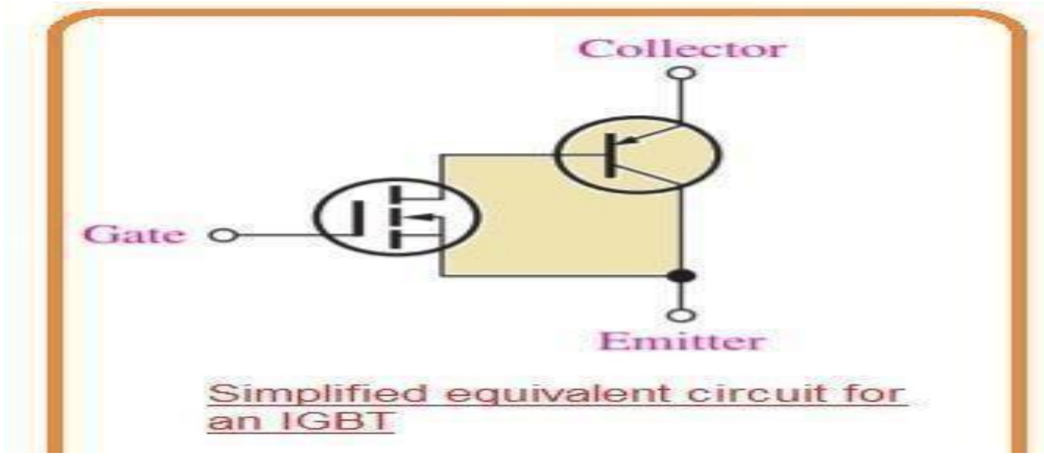
It used in high voltage switching speed applications. There are three main terminals of IGBT gate, collector and emitter.

6.1 Working of IGBT

Similar to MOSFET the IGBT is also controlled with the voltage of gate.
IGBT can be called as voltage controlled BJT with the less switching speed.
Since it is regulated by voltage at insulated gate, the insulated gate bipolar transistor does not have input current and not load the driving source.

In below figure the equivalent circuit of IGBT is shown.

- In this configuration input MOSFET and output is BJT.
- If the voltage at the gate is less than threshold voltage (V_{thresh}) with respect to emitter then it turn off.
- It turns on when by increasing voltage at gate than the threshold voltage.



Application of IGBT are:

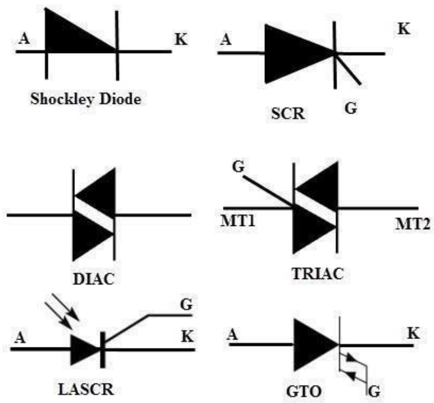
- The insulated gate bipolar transistor (IGBT) is used Ac and DC motor drivers.
- The IGBT is used in unregulated power supply (UPS) system.
- The IGBT is used to combines the simple gate-drive characteristics of MOSFET with the high-current and
- low-saturation-voltage of bipolar transistors.
- The IGBT is used in switched-mode power supplies (SMPS).
- It is used in traction motor control and induction heating.
- It is used in inverters.

6.2 THYRISTOR:

A thyristor is a four-layer semiconductor device, consisting of alternating P-type and N-type materials (PNPN). A thyristor usually has three electrodes: an anode, a cathode and a gate, also known as a control electrode. The most common type of thyristor is the silicon-controlled rectifier (SCR).

There are four major types of thyristors:

- the silicon-controlled rectifier (SCR),
- the gate turn-off thyristor (GTO) and its close relative the integrated gate-commutated thyristor (IGCT),
- the MOS-controlled thyristor (MCT) and its various forms, and (iv) the static induction thyristor (SITH).



With the advent of semiconductors manufacturing technology, current and voltage ratings of Insulated Gate Bipolar Transistor (IGBT) modules have been increased. Because of the faster switching capability, thyristors are being supplanted by the IGBTs.

Advantages of Thyristor:

- It is easy to turn on
- It is able to control AC power
- It can switch high voltage, a high current device
- It cost is very low
- It is simple to control
- It can be protected with the help of use
- It can handle large voltage, power as well as current
- It is a much smaller in size compared to the transformer
- The triggering circuit for SCR is simple

Disadvantages of Thyristor:

- It can not be negative
- It can not be used higher frequency
- It can not be easily turn off
- Gate current can not be negative
- Low switching speed

Applications of Thyristor:

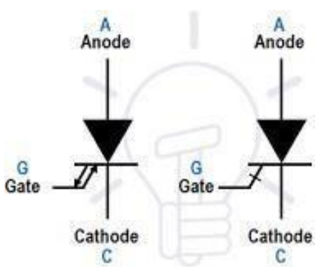
Thyristors may be used in power-switching circuits, relay-replacement circuits, inverter circuits, oscillator circuits, level-detector circuits, chopper circuits, lightdimming circuits, low-cost timer circuits, logic circuits, speed-control circuits, phase control circuits, etc.

6.3 GTO:

A Gate Turn off Thyristor or GTO is a three terminal, bipolar (current controlled minority carrier) semiconductor switching device. Similar to conventional thyristor, the terminals are anode, cathode and gate as shown in figure below. As the name indicates, it has gate turn off capability.
These are capable not only to turn ON the main current with a gate drive circuit, but also to turn it OFF. A small positive gate current triggers the GTO into conduction mode and also by a negative pulse on the gate, it is capable of being turned off. Observe in below figure that the gate has double arrows on it which distinguish the GTO from normal thyristor. This indicates the bidirectional current flow through the gate terminal.

Why GTO is used instead of Thyristor?

GTO circuit configuration or design configuration has a lower size and weight as compared to the thyristor circuit unit. The GTO unit has higher efficiency because



Gate Turn-Off (GTO) Thyristor Symbol

an increase in gate drive power loss and on state loss is more than compensated by the elimination of forced commutation losses.

Advantages:

- The gate turn OFF thyristor (GTO) has more di/dt ratings at turn ON.
- It has faster turn OFF permitting high switching frequencies.
- The communication circuit is not required, hence it reduced size, weight and cost.

- It has high efficiency.
- It has high capability of blocking voltage.

Disadvantages:

- In a gate turn OFF thyristor (GTO), ON state voltage drop and the associated loss is more.
- Gate drive circuit losses are more.
- In a gate turn OFF thyristor (GTO), magnitude of latching and holding current is more.
- Triggering gate current is higher as compared to the current required for a conventional SCR.

CHAPTER 7

AUXILIARY GATE CONTROLLER MODULE FOR TRACTION

An auxiliary gate controller module for traction typically refers to a component used in electric traction systems, such as those found in electric vehicles (EVs) or electric trains. This module controls auxiliary functions and subsystems, like heating, ventilation, air conditioning (HVAC), lighting, and other nonpropulsion systems. It ensures efficient operation and management of these auxiliary systems within the overall traction system, helping to optimize energy usage and maintain passenger comfort.

In the 6000HP Locomotives, Auxiliary Converters are used to supply three phase Auxiliary load and charge the 110VDC Battery. The Auxiliary converter units are mounted in the Machine room of the locomotive and are forced cooled. Each locomotive is equipped with identical three converters (Bur1, Bur 2 and Bur 3) each rated at 130KVA. The Auxiliary converters are powered through a separate secondary winding of the traction transformer. Input to the Auxiliary Converter is 1000VAC, 1ph, 50Hz. The output of the Auxiliary converter is 415VAC, 3Phase and

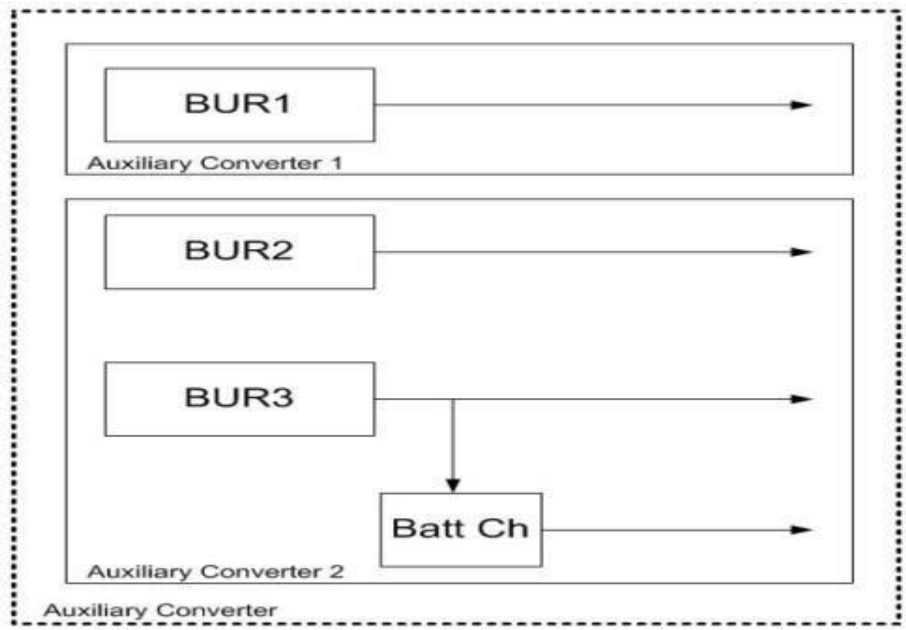
110VDc. The load distribution of the Auxiliary Converter is as detailed below

Bur 1: Water/Oil Cooling Units 1 & 2

Bur 2: Traction Motor Blower -1 & 2 Oil Pump Transformer -1 & 2 Water Pump Converter -1 & 2

Bur 3: Scavenge Blower -1 &2 Compressor -1 & 2 Battery Charger

The above Auxiliary Converters (Bur1, 2 and 3 and Battery Charger) are housed in two cabinets. Cabinet -1 will house Bur 1 and Cabinet -2 will house Bur 2, Bur 3 and Battery Charger. The cabinets are made out of Stainless steel.



General Description of Auxiliary

Converter The Auxiliary converter system is powered from an Auxiliary winding on the main transformer. Traction transformer, in addition to traction converter winding, is provided with a separate common winding for feeding the Auxiliary converters 1 & 2. The input voltage to the Auxiliaries is 1000VAC with a voltage fluctuation of 760 V to 1200V corresponding to catenary voltage variation of 19KV to 30KV respectively, 1Phase, 50Hz, +/- 6%. Auxiliary Converter 1 is also called as Bur 1 but Auxiliary Converter 2 will have Bur 2, Bur 3 and Battery Charger. The control Electronics supply is taken from the 110VDC battery (battery in customer's scope).

Each Identical Converter contains:

- Single phase input terminals
- Input fuse
- Controlled rectifier (Fully-controlled Thyristor Bridge)
- DC-link inductor
- High Voltage indicator
- Buffer capacitor (Electrolytic capacitor)
- Over-voltage protection for the DC-link, with automatic crow-bar

- Three-phase IGBT-based 130KVA inverter with Discharge resistor.
- Three-phase output filter
- Auxiliary Controller Interface
- Three-phase output terminals

The Controlled Rectifier, is a modular subsystem, converts AC input to controlled DC. It consists of a forced-air cooled, fully-controlled thyristor bridge, with stateof-the-art control and diagnostics. The unit is of robust design. It is a completely independent unit, requiring only an electronics power supply. External communication with a vehicle network is via the ACI interface controller. The DC link voltage is kept at 700 VDC. The Inverter is a modular subsystem, converts DC into 3 Phase 415V AC, 3Phase output. It consists of a classic forcedair cooled three-phase inverter, with state-of-the-art control and diagnostics. The inverter uses IGBT’s as power switches. The unit is of robust design. It is a completely independent unit, requiring only an electronics power supply. External communication with a vehicle network is via the ACI interface controller. The Buffer module stores energy to assist the control system in lineinterruption ride-through. The unit also includes the over-voltage crow-bar.

In the context of traction systems, auxiliary gate controllers are essential for several reasons:

1. *Safety:* Traction systems, such as those used in railways or transit systems, require a high level of safety. Auxiliary gate controllers help manage access to critical areas like tracks, maintenance zones, or electrical substations, preventing unauthorized personnel from entering these potentially hazardous locations.

2. *Access Control:* Traction systems often have restricted areas that only authorized personnel should enter. Axillary gate controllers ensure that only employees with the necessary credentials or training can access these areas, reducing the risk of accidents or incidents.

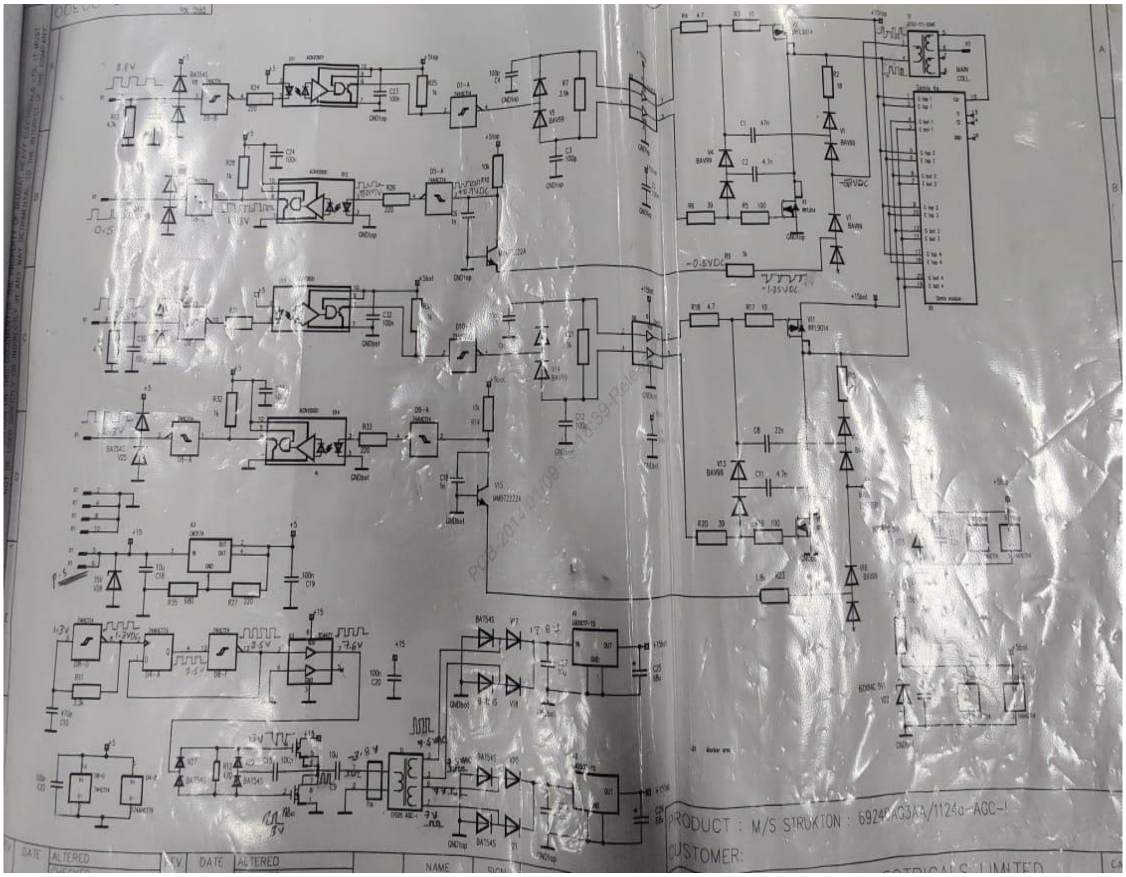
3. *Security:* Protecting the infrastructure of a traction system is vital. Auxiliary gate controllers help prevent vandalism, theft, or sabotage by controlling access to sensitive equipment and facilities.

4. *Operational Efficiency:* Gate controllers can help manage the movement of vehicles and personnel within a traction system, ensuring a smooth flow of operations. This is particularly important in busy transit hubs or maintenance yards.

5. *Data Logging:* Many auxiliary gate controllers are equipped with data logging capabilities. This data can be used for security audits, tracking the movement of personnel and vehicles, and improving overall system efficiency.

6. *Integration:* These controllers can be integrated with other systems within the traction infrastructure, such as signal control systems or security cameras, to create a comprehensive and interconnected safety and security network.

In summary, auxiliary gate controllers are a crucial component of traction systems, ensuring safety, security, and efficient operations while helping to manage access to critical areas within the infrastructure.



The components used in AG3AA are listed below:

- Resistor
- Capacitors
- Semix module
- BAT54S
- ACNV2601
- 74HCT14
- BAV99
- TC4426/TC4427/TC4428
- IRFL014
- MMBT2222A

- 74AHCT14
- SEMiX family

7.1 Hardware

BAT54S

The BAT54S is a Planar Schottky barrier diode with an integrated guard ring for stress protection, encapsulated in a small SOT23 (TO-236AB) Surface-Mounted Device (SMD) plastic package. This series comes in different part numbers:

BAT54, BAT54C, BAT54A.

ACNV2601

The ACNV2601 is an optically coupled gate that combines a AlGaAs light emitting diode and an integrated photo detector housed in a widebody package. The distance-through-insulation (DTI) between the emitting diode and photo-detector is 2mm. The output of the detector IC is an open collector Schottky clamped transistor.

74HCT14

The 74HCT14 provides provides six independent Schmitt trigger input inverters with standard push-pull outputs. The device is designed for operation with a power supply range of 4.5V to 5.5V. The gates perform the Boolean function: AY.

BAV99

The BAV99 is a surface mount dual Small Signal Switching Diode encapsulated in a moulded plastic case. It has matte tin (lead-free plating) annealed over alloy 42 lead frame terminals. It is ideally suited for automated insertion. It can also be used for general purpose switching applications.

TC4426/TC4427/TC4428

The TC4426/TC4427/TC4428 devices have matched rise and fall times when charging and discharging the gate of a MOSFET. These devices are highly latchup resistant under any conditions within their power and voltage ratings

IRFL014

Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance, and cost-effectiveness. The SOT-223 package is designed for surface-mounting using vapor phase, infrared, or wave soldering techniques.

MMBT2222A

The MMBT2222A from Fairchild is a surface mount, NPN general purpose amplifier in SOT-23 package. This device is suitable for medium power amplification and switching applications.

74AHCT14

74AHCT14 is a hex inverter with Schmitt-trigger inputs. Inputs are overvoltage tolerant. This feature allows the use of these devices as translators in mixed voltage environments.

SEMiX family

The SEMiX family includes uniform IGBT and rectifier housings. Virtually all have the same height (17mm) and the power terminals can be connected by one principle DC-link design. This saves development time and makes a simple, low inductance DC-link profile possible.

7.2 Testing Procedure for AG3AA With result

7.2.1. Introduction

This document describes the routine test for the Auxiliary IGBT driver (1123 AGCI) PCB. The routine test consists of the following steps:

- Visual inspection (§ 3)
- Performance test (§ 4)
- Burn in (§ 5)
- Performance test (§ 4)

All tests are carried out according to IEC 60571.

The high voltage test of the AGC-I is carried out when the AGC-I is mounted in the power module

7.2.2. PCB marking

On the Silkscreen of the PCB the following line is printed:

ABCDEF 1234 BHT

With a permanent marker pen there must be marked: One of the letters A-F, depending on the PCB layout variant.
-The letter B when the PCB has had a burn-in test.

- The letter H when the PCB has passed the insulation test. (not applicable for the 1123 AGC-I)
The letter T when the final performance test is done.

- The numbers 1-4 are used to indicate that a PCB is modified after production.

7.2.3. Visual inspection

The printed circuit board must be carefully viewed:

- No cracks may be seen in board, tracks or components.
- No deformed, loose or missing components
- No short circuits by soldering material or else. No conformal coating or other materials on contact surfaces.
- The label with serial number must be present.
- The variant letter must be marked as indicated in section 2.

7.2.4. Performance test

4.1 Required equipment

1 x supply 0..30V 1A

1 x digital oscilloscope 2 channel

Test box AGC-I

7.2.5 Test Set-up

Connect the oscilloscope with three coax cables to the test box

Three coax cables are connected to channel A, B (5V) div) and a trigger input of the and oscilloscope channel A -5vldiv

-AC coupling

- vert position: 5ndDiv, from the top

Channel B:

-5v/div

-Ac coupling

-vert, position :3rd div. from the top

Configure the trigger:

-Ac coupling

- positive edge

-Level 0v

-hor position and div

-Time base: 2us/div

Connect a power supply to the test box`. Current limitation 0.5 A power supply can be switched on. The text box is equipped with supply switch 51. If this is set to 0 the supply on the test box is switched off

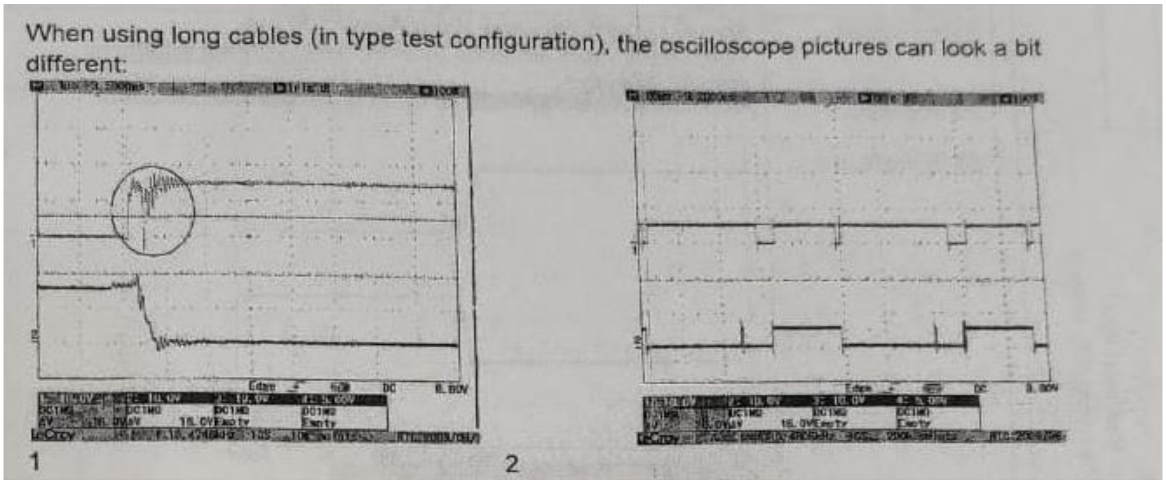
Test Procedure

Switch ON to OFF

place the PCB under test on the test box. Secure it with a nut in the center. connect the connector x1

connect the appropriate connection points on the test box with two cable lugs. Fasten. the nuts Chard tight)

put switch s2 to 1,S3 to E



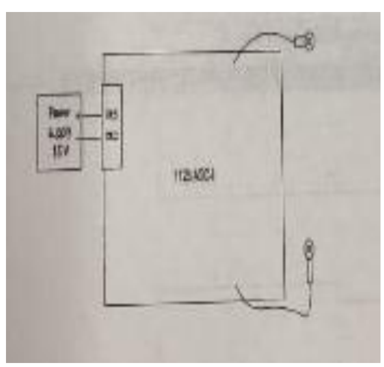
- Glitches at leading edge (Picture 1)
- Lower pulse can be divided in two pulses (Picture 2)

<u>Burn IN</u>

This test is part of the equipment stress screening and may only be executed once.

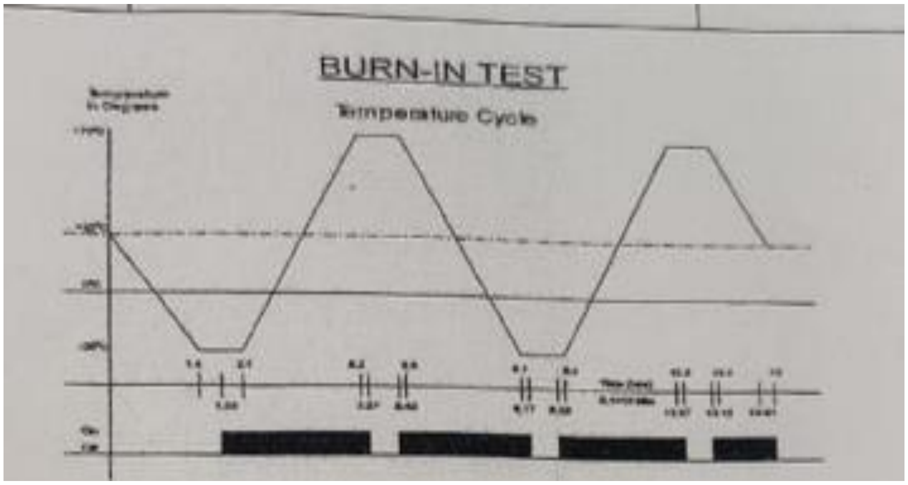
When for any reason the routine test is repeated, the burn-in must be skipped.

During the burn-in the following connections must be made:



Place the AGC-I in a temperature chamber. The temperature cycle must be programmed according to the following diagram:

BURN-IN-TEST

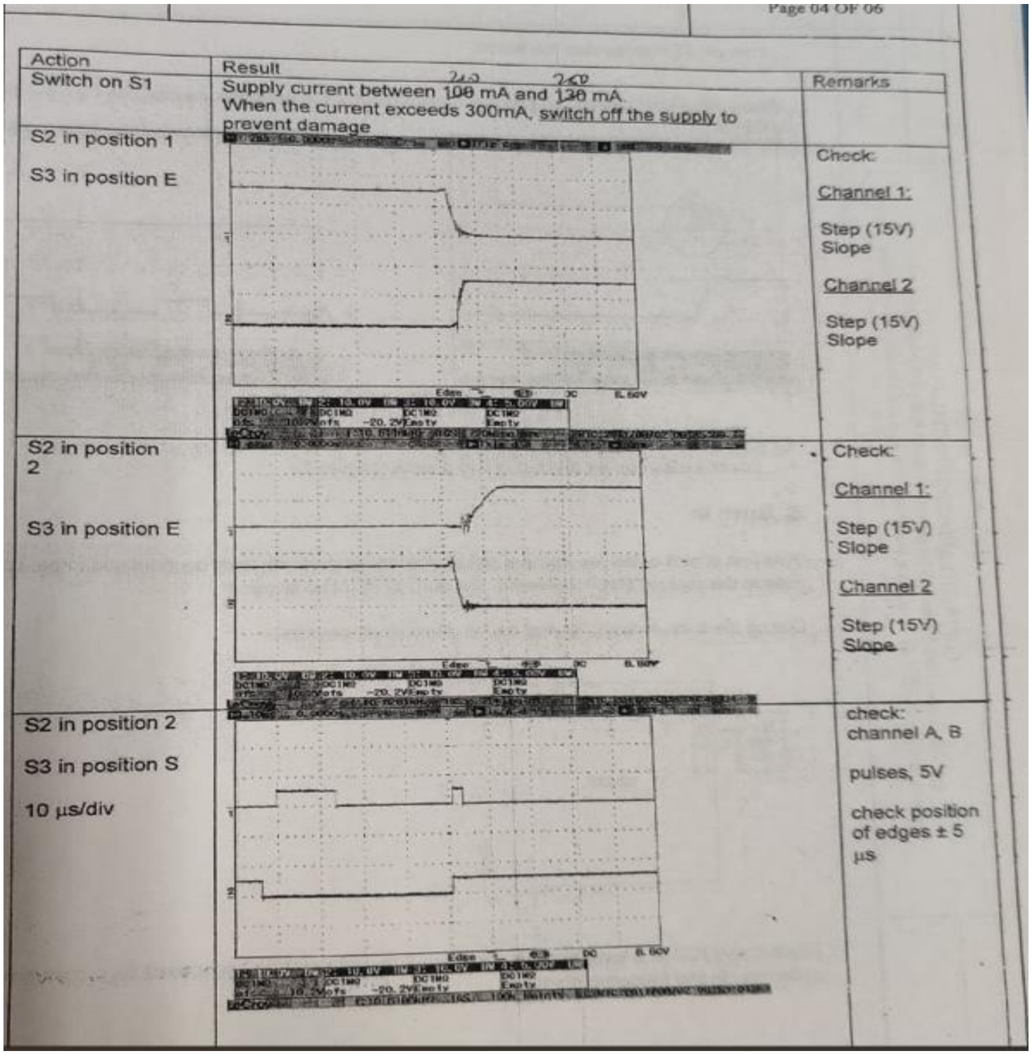


After burn-in, the B on the ID-tag must be marked

7.2.6 .Final actions

After repeating the performance test, the T on the ID tag must be marked

7.3 Test result



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Action	Result	Remarks
Switch on S1	Supply current between ~~100~~ 210 mA and ~~130~~ 250 mA. When the current exceeds 300mA, switch off the supply to prevent damage	
S2 in position 1 S3 in position E		Check: Channel 1: Step (15V) Slope Channel 2 Step (15V) Slope
S2 in position 2 S3 in position E		Check: Channel 1: Step (15V) Slope Channel 2 Step (15V) Slope
S2 in position 2 S3 in position S 10 µs/div		check: channel A, B pulses, 5V check position of edges ± 5 µs

CONCLUSION

This internship has been a real eye opener as to how the industry works and especially at BHEL- EDN which houses several departments, a true display of how each department works in a coordinated and efficient manner was shown. It has helped my engineering knowledge in practical ways with subjects that were taught in my undergraduate course, like Control Systems and VLSI designs. Working and learning alongside experience professionals has been an amazing and knowledgeable experience. I can honestly say that my time spent interesting with BHEL resulted in one of the best time. Overall, my internship at BHEL has been a success. I was able to gain practical skills, learn in a fantastic environment. A brief description of all the things that were demonstrated and taught in my 4-week internship has been documented in this report

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