EE236 COURSE OUTLINE

July 30, 2024

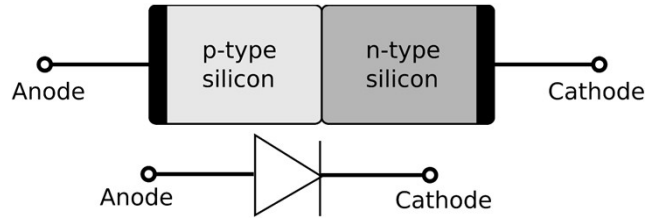
Electronic Devices Lab – EE 236

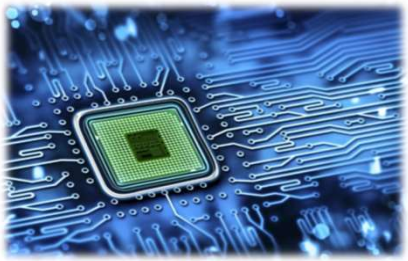
Course Instructors:

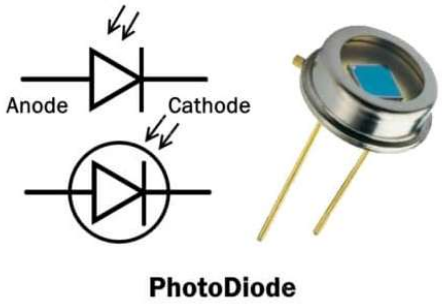
Prof. Apurba Laha (laha@ee)
Prof. Pradeep Nair (prnair@ee)

Why should you attend this lab?

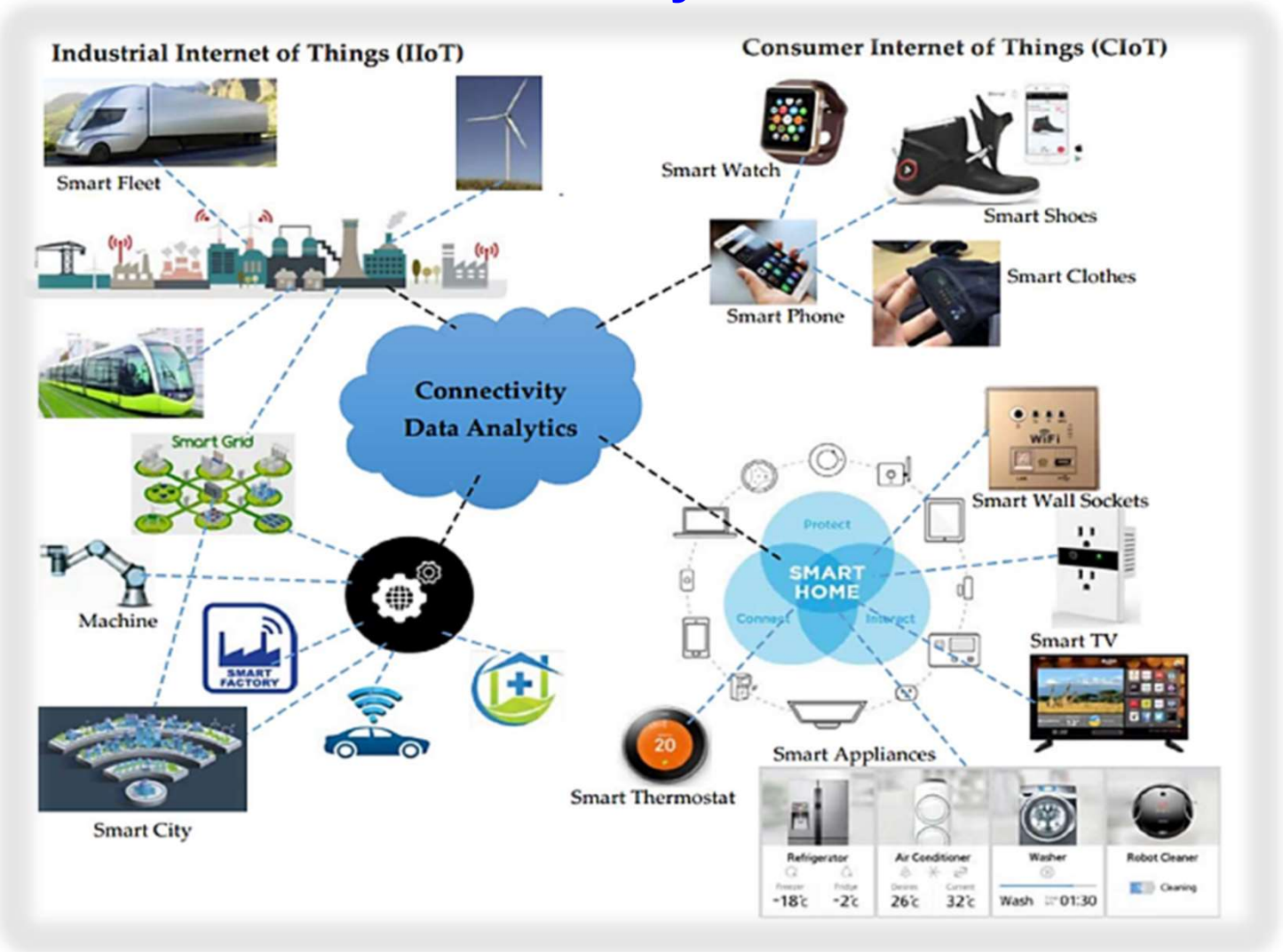
- *Google operates an estimated 2-2.5 million custom servers distributed across more than a dozen data centers worldwide to handle a wide range of tasks from search queries to data storage and processing for various Google services.*
- *Each server has 2-4 microprocessor (Intel Xeon, 20-30 Billion Transistors)*
- **Apple M1 Ultra (2022):** This processor has around 114 billion transistors, making it one of the most densely packed chips in consumer electronics.
- **NVIDIA A100 (2020):** A high-performance GPU used in AI and data centers has around 54 billion transistors.



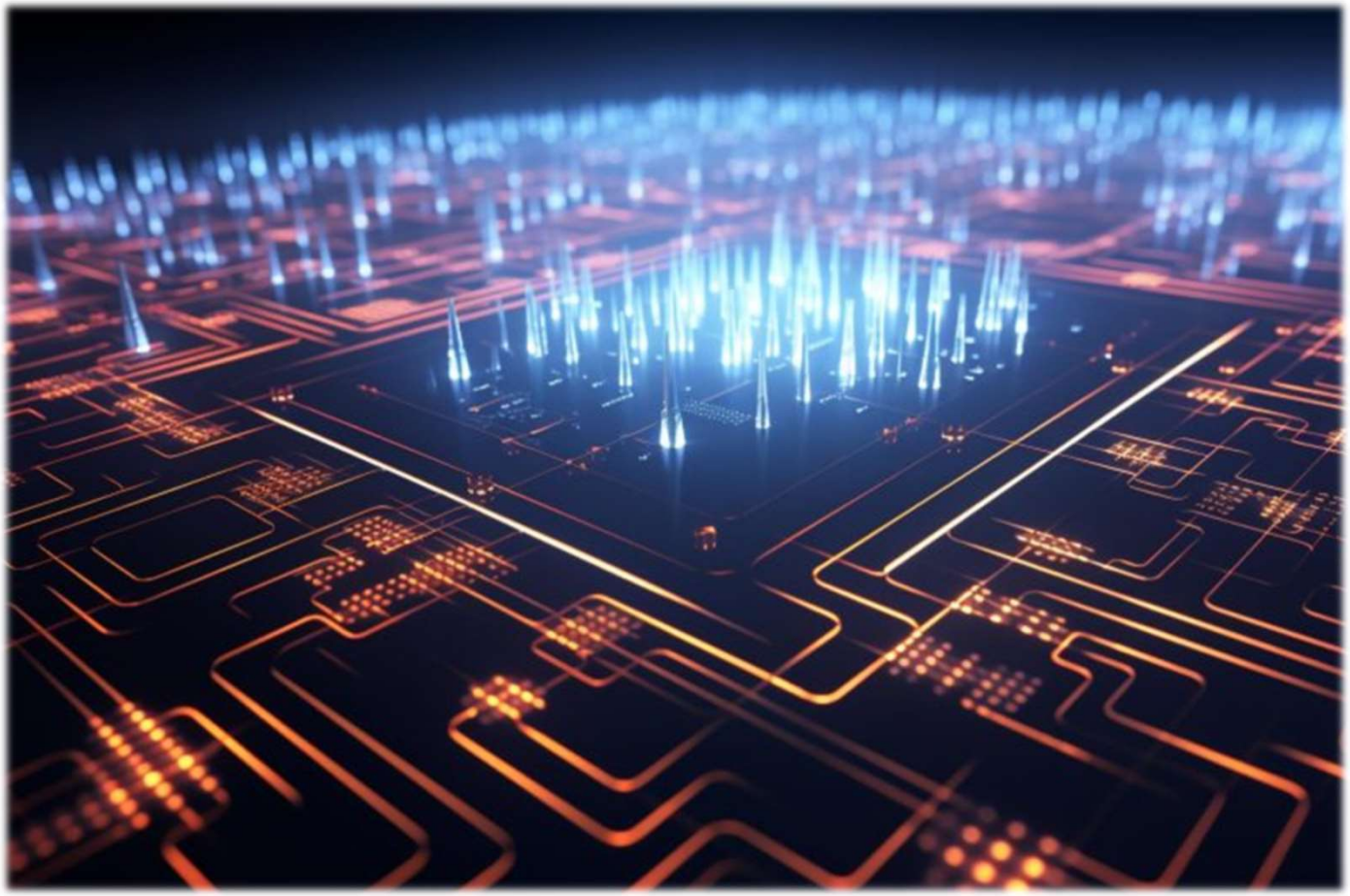




Modern communication system



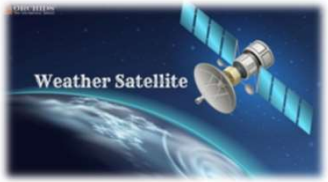
Quantum Well Nanowire Array Micro-LEDs: The Future of On-chip Optical Communication



Modern communication systems

- **Wireless Communication Systems**

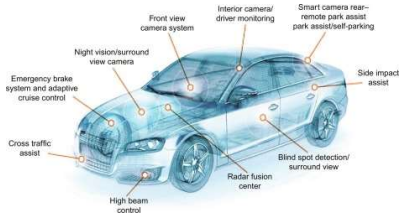
- **Satellite Communications**:



- **Fiber Optic Communication**:

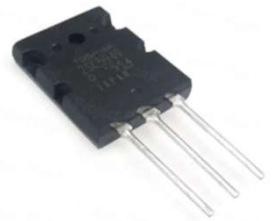
- **Microwave and Millimeter-Wave Circuits**

- **Automotive Electronics**:



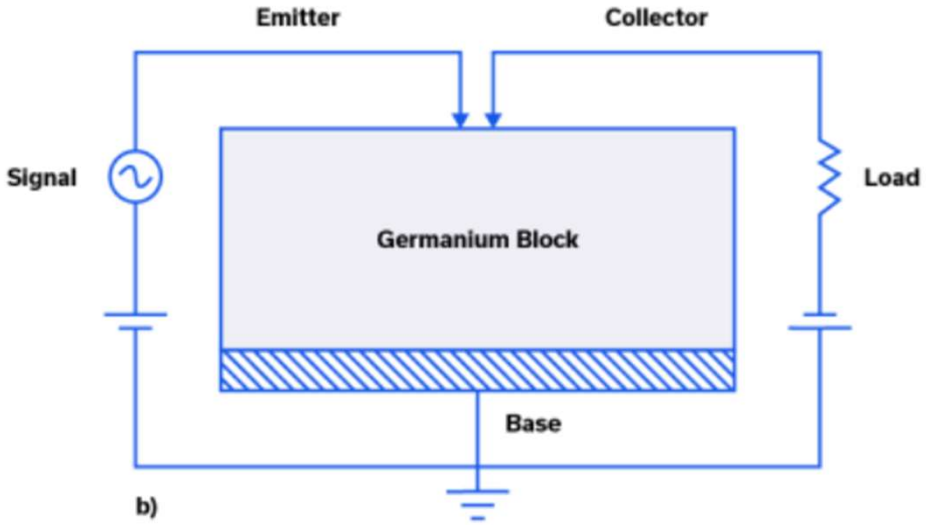
- **High-Speed Digital Circuits**

- **Power Amplifiers**:



What is the component?

a)



b)

HBT: Heterojunction Bipolar Transistor

INTRODUCTION

- "In theory, theory and practice are the same. In practice, they are not."
- **We will have all lab sessions and exams in offline mode.**
- We will have few pre-lab simulation exercises, and also in the exam, to give you a better understanding of the theoretical concepts and/ or verify expected practical results

LEARNING OBJECTIVES

After completing EE 236 course you will learn:

- **Device characterization**: Conduct basic electrical measurements of electronic devices such as PN junction diodes, Zener diodes, LEDs, Schottky diodes, Photo diodes, PIN diodes, Solar cells, BJTs & HBTs, MOSCAP, MOSFETs, Hall-sensors etc.

- **Application of device concepts**: Analyze measured data through simulations/ real experimentation and obtain device parameters (band gap of a diode, carrier lifetime in a photodiode, transient analysis, solar cell fill factor, transistor mobility, body bias effect etc.)

- **Simulations**: Use ngspice/ NanoHub simulations tools to characterize device performance and its impact on circuit response

- **Data representation**: Use plotting software such as Gnuplot/ Origin, technical writing skills (latex)

LOGISTICS

- The class is divided in 2 batches**.**
- Lab sessions: **Monday- BTech and Tuesday- Dual Degree (2 pm to 5 pm)**

(Detailed schedule for each lab-session, quizzes, exam plans will be discussed towards the end of session and will be made available on moodle).

- You will be working in a group of 2 during the hands-on lab sessions. Each student will be assigned to a TA-RA to manage the logistics during lab sessions, handle queries and lab-session evaluations. **Pre-lab simulation exercises will be individual.**
- Course material and announcements will be posted on moodle.
- Lecture (offline-session: 15-20 min, wherever necessary) will be conducted before start of the lab-session to fill-up the gaps, if any, between theory and the lab experiment.

LAB TOOLS REQUIRED

- Each individual student is expected to have a set of tools given below before Aug 4th (before next lab session on Monday or Tuesday).
- It will be needed to take multiple simultaneous measurements during experimentation.
- Also, these will serve you well in all your future WEL Lab courses.
- List of recommended tools with images and availability on online portals/ local market is given in the next few slides. **You can explore some other options.**

Basic tools required:

1) DMM: Mastech MAS830L or equi. (Price range: Rs. 650 to 900)
2) Wire Stripper: Stanley/ Taparia/ Multitec or equi. (Rs. 50 to 100)
3) ESD angled tweezer: Any brand, but ESD important (Rs. 80 to 120)
4) Solderless Breadboard: WISH/ DOAT are better quality [other may create problems later on (Rs. 150 to 250)
5) Tester cum screw driver: Taparia/ Multitec or equi. (Rs. 70 to 90)
6) Plastic container to carry the tools (1 no.)

Tool set for Electronics Lab

Digital Multimeter (DMM)

Wire Stripper

Solderless Breadboard

ESD angled tweezer

Line Tester cum screw driver

* Images are give for your reference

** Price ranges are given to get an idea about the amount needed to procure it.

** Some products are available in the low-cost range (possibly fake/ low quality) and will go bad anytime (mainly in case of DMM and breadboard). **So buy it carefully.**

e.g. Mastech DMM are available in the market with different manufacturer name and with same or similar model name.

** Best place to purchase the electronics components (locally) is Lamington Road, Mumbai.

** Few known vendors at Lamington Road (Nearest local train station: Grant Road)

1) Gala Electronics

2) Visha Electronics (Both on the 1st floor of Kalpana Building, opp. Bhadkamkar Police station, Lamington road)

** You can also explore some other shops at Lamington road and online websites < https://robu.in/> or https://www.electronicscomp.com/, etc.

FOR EACH LAB SLOT: Pre-lab reading (supporting material will be uploaded) and post-lab work (experimental results, plots, report) will be assigned for each experiment.

- **We will conduct quizzes (2) of 20-30 min. duration [may or may not have simulation component] to check your conceptual understanding, test your preparedness and to check your regular progress in the course**

  [Dates are mentioned in the course schedule].

DURING YOUR LAB SLOT

- **All the lab-sessions are mandatory. Attendance will be taken by the lab staff.**

- Reporting time to the lab- 2 PM (sharp). In case of any delays, 5 min. buffer time will be considered. Beyond that you will not be allowed entry to the lab and you will be marked ABSENT for that particular lab session.

- **No penalty for making mistakes during the lab. Learn from your mistakes. Document your mistakes honestly in your reports.**

- You must finish your work in your allotted slot. Extension requests will not be entertained. **If you want to practice and gain hands-on experience, you are free to use the morning slot on the weekdays in WEL.**

- Before you leave the lab after your lab slot, you must upload your experimental data, plots, waveform on moodle after demonstration and verification from your assigned TA. **TAs will put the time stamp and sign on their record sheet.**

- **We will check your lab reports against your submitted data for academic integrity.**

LAB DISCIPLINE – AFTER YOUR LAB SLOT

- Post lab work will be **due on Saturday afternoon, 12 pm** for each experiment performed on Monday or Tuesday.

- Reports **must** be written in Latex, plots **must** be drawn in GNU plot or any other professional plotting software, circuit diagrams **must** be drawn with Xcircuit or any other professional circuit maker tool. Documents written in MS Word/ Excel plots/ Libre office will not be accepted. **(Template for Latex report is already known to you from previous semesters, else it will be provided).**

- **We will use Turnitin or equivalent software and heavily penalize those found guilty of plagiarism (both supplier and recipient).**

- **Emphasis will be on writing style and content. If your simulation/ experiment does not work, debug and write down your observations and hypotheses.**

- **The goal is not to finish the simulation/ experiment blindly, but to learn from the experience. *No marks will be deducted* if your simulation/ experiment doesn't work as expected, if you clearly reason out what you tried and where you might have gone wrong.**

DOCUMENTATION

- Upload your in-session and post-lab work on moodle page for EE236. The upload link will be created every week with appropriate deadlines.

- **Report should be written individually.**

- **No credit for late submissions (even a few seconds late is technically late). Start working on your reports well in advance of the deadline. Respect deadlines.**

LAB DISCIPLINE

- Attendance is **mandatory.**
- If you cannot attend a lab session (due to genuine reasons), inform stakeholders **at least 1 day in advance (email mode only).**
  - Stakeholders are your course instructors, Mr. Mahesh and RA-TA
  - **Intimation of absence in advance is not equivalent to approval**

  *** Genuine case is only medical reason that too a proof from IITB Hospital, i.e., IITB Hospital PINK Slip only**
- If your absence is approved, complete your work including uploading of the postlab work before the next lab turn
  - Failure to do so will disqualify your credits for the lab you missed
  - It is your responsibility to coordinate with your TA for mutually convenient slot. You must keep the course instructors and Mr. Mahesh in the loop on all communication.

GRADING POLICY (TENTATIVE)

In session marks: **25**% (Approx. 11-12 lab sessions)

[Each experiment carries 20 points with – 15 pts. for in-session work (including pre-lab, if any) shown to TA, 5 pts. for post-lab work (lab report)]

Quizzes: **20**% (2-Quizzes- Weightage: 10% each, 26-27th Aug & 14-15th Oct)

Mid semester: **20**% (Sep 29, Sunday)

End semester Exam: **35**% (Oct 26, Saturday)

Course Schedule

Experiment No.	Batch-A (Monday) B. Tech. Batch	Batch-B (Tuesday) Dual Degree Batch	Experiment
Exp 0	29-Jul	30-Jul	Course Outline and Ngspice: Diode IV characteristics, RC LPF and band gap and Nanohub
Exp 1	05-Aug	06-Aug	Diode IV characteristics and LED band gap
SIMU-1			**Simulation Exercise – Nanohub**
Exp 2	12-Aug	13-Aug	PIN diode characteristics & RF switch
Exp 3	19-Aug	20-Aug	Photo Diode Characteristics (& Application of Photodiode)
Exp 4	26-Aug	27-Aug	I-V characteristics of solar cell (+Quiz-1 on 26th & 27th Aug for both batches: 20-30 min. before start of lab session)
Exp 5	02-Sep	03-Sep	Temperature dependence of solar cell
Exp 6	09-Sep	10-Sep	Schottky Diode transients and C-V characteristics of Schottky diode
Exp 7	23-Sep	24-Sep	BJT & HBT DC Characteristics
29-09-2024 (Sunday) (Tentative)			**Mid-sem practical exam**
SIMU-2			**Simulation Exercise – Nanohub**
Exp 8	30-Sep	01-Oct	NMOS I-V characteristics and body effect
Exp 9	07-Oct	08-Oct	MOSCAP C-V characteristics
Exp 10	14-Oct	15-Oct	NMOS temperature dependence (+Quiz-2 on 14th and 15th Oct for both batches: 20-30 min before start of lab session)
Exp 11	21-Oct	22-Oct	NMOS Subthreshold Characteristics
Exp12	28-Oct	29-Oct	HALL Sensor Characteristics
26-10-2024 (Saturday)			**End-Sem practical exam**

How does an experimentalist think?

- **Aim:**
  - What do we seek to measure?
- **Apparatus:**
  - What devices, instruments do I need?
- **Experiment:**
  - What measurements must I conduct?
  - What is the right way to obtain these measurements?
  - What is the accuracy of my measurement? What errors are present in my experimental data?
- **Observations/Data interpretation:**
  - What does my data tell me? Is it what I expected?
  - How must I visualize my data to obtain insights/information?
- **Conclusions**
  - Based on my experiment, what inferences can I draw?
  - How can I improve my experiment in future? What breakthroughs are needed?