প্রবাহ

PROBAHO'24

B.P PODDAR INSTITUTE OF MANAGEMENT & TECHNOLOGY

Department of Electrical Engineering

EDITORIAL TEAM

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Department of Electrical Engineering
B.P Poddar Institute of Management & Technology

B. P. Poddar Institute of Management & Technology
Department of Electrical Engineering

VISION

To emerge as a knowledge hub for higher learning and research in Electrical Engineering.

MISSION

·To create a conducive quality teaching –learning environment to make the student assimilate thorough knowledge in Electrical Engineering.

·To create a platform for building confidence among faculties and students by exchanging their views through research, interactive sessions with industry and by the use of modern tools.

·To adopt a goal driven teaching learning method to foster innovative entrepreneurship skills in student community with expertise in different engineering domains.

·To enable students to become authorities in the field of Electrical Engineering along with sustainable and environment friendly technologies to meet the societal needs.

B. P. Poddar Institute of Management & Technology
Department of Electrical Engineering

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Acquire adequate physical, analytical and technical knowledge of Electrical Engineering and allied fields to curate solutions which effectively address the challenges posed by dynamic work environments.

PEO 2: Inculcate self- assurance, collaborative spirit, critical thinking and acumen for innovation towards gaining a competitive edge in research and development as well as in entrepreneurial ventures.

PEO 3: Imbibe professional ethics and the attitude to bank on sustainable and eco-friendly practices only, for the wellbeing of society at large.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: The students will enhance their knowledge and acquire skills on Power System, Measurement and Control, Signal Processing Techniques and Automation to contribute in the field of Electrical Engineering and evolving domains like Renewable Energy Systems, Intelligent Systems, Health care and e-mobility sectors and emerge as successful entrepreneurs as well.

PSO 2: The students shall apply their knowledge to pursue successful careers with Academia and R & D Laboratories across the globe, endorsing clean and eco-friendly technologies.

ACKNOWLEDGEMENT

The publication of the 19th edition of Probaho has been made possible through the collective effort, encouragement, and support of many individuals associated with the Department of Electrical Engineering. We take this opportunity to express our sincere gratitude to the Head of the Department and all the respected faculty members for their constant guidance and inspiration throughout the preparation of this magazine.

We are equally thankful to the respected faculty members and students whose enthusiasm, creativity, and contributions have added great value to this edition. Their participation reflects the vibrant spirit of our department.

—From the Editors

To the Readers

Probaho, a Bengali word meaning "flow", represents continuity, transformation, and progress. Since its inception in 2005, this departmental magazine has carried forward a legacy of ideas, creativity, and expression, evolving with every passing year.

The year 2024 marks a phase where technology is not just advancing but redefining the way we perceive the world. As students of Electrical Engineering, we stand at the intersection of innovation and responsibility. From classrooms to laboratories, from circuits to systems, our journey has been shaped by curiosity, collaboration, and constant learning.

This edition of Probaho reflects that spirit of transformation. With a focus on emerging technologies such as electric vehicles, sustainable energy, and intelligent systems, the magazine captures how engineering is driving the future. It brings together thoughts, technical insights, and creative expressions that highlight both academic learning and individual perspectives.

Beyond academics, this journey has also been about experiences—late-night preparations, discussions with peers, challenges that tested us, and moments that defined us. These experiences form the essence of our growth, shaping not only engineers but individuals.

As we present this edition, we acknowledge the efforts of everyone who contributed to this collective work. We hope Probaho'24 resonates with its readers and continues the flow of knowledge, innovation, and inspiration for the years to come.

Sougata Roy Chowdhury
(Member of Editorial Team
Electrical Engineering)

HOD'S COLUMN

In today's dynamic world, a 360 degree development and grooming is of supreme importance and through our department we are creating an environment for future leaders, entrepreneurs and professional who possess skills and aptitudes in an array of functional disciplines other than domain knowledge. We are partners in learning with our students and seek to deepen their knowledge, provide enriching and innovative learning experiences, while also gently urging our students to come out of their comfort zone to attempt new challenges. Publishing a college magazine is vital for fostering student creativity, providing a platform for expression, and documenting campus life. It helps hone writing, editing, and teamwork skills, offering practical experience in publishing. The magazine serves as a launchpad for students to showcase latent creative talents through poems, articles, short stories, and artwork. Students involved in the editorial board and content creation gain valuable professional experience in writing, editing, graphic design, and publishing, which are directly applicable to the workforce. It promotes critical thinking, fosters an environment.

I understand that our students have brainstormed a lot to select Electric Vehicle the theme of 'Probaho 2024' .Electric vehicles (EVs) have zero tailpipe emissions, significantly reducing CO2 and pollutants, which helps fight climate change and improves public health. EVs have lower running and maintenance costs compared to internal combustion engines (ICE) because they have fewer moving parts and electricity is generally cheaper than petrol or diesel.

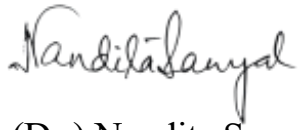
Transitioning to electric mobility helps nations reduce their dependence on imported oil, improving energy security.E-mobility complements the use of renewable energy sources, such as solar power, for charging, making the entire transport cycle more eco-friendly.Driving an electric vehicle can help you reduce your carbon footprint because there will be zero tailpipe emissions.

The National Electric Mobility Mission Plan (NEMMP) 2020, launched in 2013, is a Government of India initiative to foster sustainable transportation, reducing crude oil imports. It focused on indigenizing technology, infrastructure development, and emissions reduction. The FAME India Scheme (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) was established in 2015 to provide demand incentives for accelerating the adoption of EVs.

India presently grapples with a host of environmental issues such as deteriorating air quality in cities. The transport sector contributes an estimated 142 million tonnes

of carbon dioxide emissions every year, out of which the road transport segment alone contributes nearly 123 million tonnes. The Government of India envisions to replace 30 percent of its automobile fleet with electric vehicles by 2030 for powering its vision of building a sustainable transportation system and lowering carbon emissions.

However, achieving India's vision of green mobility warrants a synergy between all the stakeholders – automotive manufacturers, academia, and policymakers. By bringing social innovation in the mobility sector, We should aim to create an impact ful sustainable framework for e-mobility in India and accelerate India's journey towards achieving a carbon-neutral environment. I congratulate the editorial board of 'Probaho 2024' from core of my heart for their sincere effort to publish such a vibrant informative Magazine Probaho 2024. Its our responsibility to Sustain the practice of publishing such magazine in coming years.



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Department of Electrical Engineering

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Assistant Professor
Department of Electrical Engineering
B.P. Poddar Institute of Management and Technology

AI কি চাকরি হারানোর জন্য দায়ী, নাকি এটি একটি সুযোগ?

বর্তমান যুগকে অনেকেই "প্রযুক্তির যুগ" বলে থাকেন। কিন্তু সত্যি বলতে, আমরা শুধু প্রযুক্তির যুগে বাস করছি না —আমরা বাস করছি কৃত্রিম বুদ্ধিমত্তা (Artificial Intelligence বা AI)-এর যুগে। যেই প্রযুক্তি কয়েক বছর আগেও শুধুমাত্র কল্পবিজ্ঞানের গল্পে সীমাবদ্ধ ছিল, আজ সেটাই বাস্তবের চাকরি, ব্যবসা, শিক্ষা, চিকিৎসা, এমনকি মানুষের দৈনন্দিন জীবনের অবিচ্ছেদ্য অংশ হয়ে উঠেছে। তবে AI-এর বিস্তার যত বাড়ছে, মানুষের মনে ততই একটি প্রশ্ন জেগে উঠছে—

AI কি মানুষের চাকরি কেড়ে নিচ্ছে? নাকি AI আমাদের জন্য নতুন সুযোগ সৃষ্টি করছে?

এই প্রশ্নের উত্তর সহজ নয়। কারণ AI একদিকে যেমন চাকরির কিছু ক্ষেত্র সংকুচিত করছে, অন্যদিকে নতুন কর্মক্ষেত্র ও দক্ষতার দরজা খুলে দিচ্ছে। তাই AI কে শুধুমাত্র "চাকরি ধ্বংসকারী" বা "সুযোগ সৃষ্টিকারী" হিসেবে একপেশে বিচার করলে বাস্তবতা ধরা পড়বে না। বরং আমাদের দেখতে হবে, AI আসলে কীভাবে শ্রমবাজারকে পরিবর্তন করছে এবং মানুষ কীভাবে এই পরিবর্তনের সঙ্গে খাপ খাইয়ে নিতে পারে।

AI এবং চাকরি হারানোর আশঙ্কা: বাস্তবতা কতটা সত্য?

AI-এর সবচেয়ে বড় প্রভাব পড়েছে এমন কাজগুলোতে, যেগুলো পুনরাবৃত্তিমূলক (Repetitive), নিয়মভিত্তিক (Rule-based), এবং যেগুলোতে মানবিক সৃজনশীলতা বা আবেগের ভূমিকা কম। যেমন — ডেটা এন্ট্রি (Data entry), কাস্টমার সার্ভিস (Customer Service), ব্যাংকের কিছু রুটিন কাজ , টোল প্লাজা বা টিকিটিং সিস্টেম, কারখানার অ্যাসেম্বলি লাইনের কাজ,সাধারণ হিসাবনিকাশ বা বুককিপিং|

আগে যেখানে একজন কর্মচারী ঘণ্টার পর ঘণ্টা ধরে তথ্য টাইপ করতেন বা হিসাব করতেন, এখন AI এবং অটোমেশন সফটওয়্যার কয়েক সেকেন্ডে সেই কাজ করে ফেলতে পারে। ফলে বহু প্রতিষ্ঠান কম খরচে দ্রুত কাজ শেষ করতে AI ব্যবহার করছে। এতে শ্রমিক ও কর্মচারীদের একটা অংশ সত্যিই চাকরি হারাচ্ছে।বিশেষ করে উন্নয়নশীল দেশগুলোর ক্ষেত্রে এই ঝুঁকি আরও বেশি, কারণ এখানে অনেক মানুষ স্বল্প দক্ষতার কাজের ওপর নির্ভরশীল। AI যখন সেই কাজগুলোকে প্রতিস্থাপন করছে, তখন সামাজিকভাবে একটা বড় চাপ তৈরি হচ্ছে । এছাড়া, AI এখন এমন পর্যায়ে পৌঁছেছে যেখানে এটি শুধু রুটিন কাজ নয়, বরং কিছু মেধাভিত্তিক কাজও করতে পারে। যেমন— রিপোর্ট লেখা, সাধারণ ডিজাইন

তৈরি, অনুবাদ, ভিডিও এডিটিং, মার্কেটিং কন্টেন্ট তৈরি, প্রাথমিক কোডিং এই ক্ষেত্রগুলোতে AI-এর প্রবেশ অনেক মানুষের মধ্যে ভয় তৈরি করেছে—"তাহলে কি সাংবাদিক, লেখক, ডিজাইনার বা প্রোগ্রামারদেরও আর দরকার হবে না?"

এই ভয় সম্পূর্ণ অমূলক নয়। কারণ প্রযুক্তির ইতিহাস বলে, নতুন প্রযুক্তি এলে পুরোনো কিছু পেশা বিলুপ্ত হয়। যেমন টাইপরাইটারের যুগ শেষ হয়ে গেছে, ডাক বিভাগের চিঠি লেখার কাজ কমে গেছে, ফটোগ্রাফারদের অনেক কাজ মোবাইল ক্যামেরা সহজ করে দিয়েছে। AI এই পরিবর্তনকে আরও দ্রুত করছে।

AI কি সত্যিই চাকরি কেড়ে নিচ্ছে, নাকি কাজের ধরন বদলে দিচ্ছে?

এখানে একটি গুরুত্বপূর্ণ বিষয় বুঝতে হবে। AI আসলে সব চাকরি কেড়ে নিচ্ছে না—বরং অনেক ক্ষেত্রে এটি চাকরির কাজের ধরন (Job role) বদলে দিচ্ছে।যেমন, আগে একজন হিসাবরক্ষককে (Accountant) অনেক সময় ধরে ক্যালকুলেশন করতে হতো। এখন সফটওয়্যার সেই কাজ করে দেয়। কিন্তু হিসাবরক্ষকের ভূমিকা শেষ হয়ে যায়নি। বরং এখন হিসাবরক্ষককে আরও বেশি মনোযোগ দিতে হচ্ছে— আর্থিক বিশ্লেষণে, কর পরিকল্পনায়, ব্যবসায়িক পরামর্শে, অডিট এবং ঝুঁকি মূল্যায়নে অর্থাৎ AI মানুষের কাজ সহজ করেছে, কিন্তু মানুষকে আরও দক্ষ ও বিশ্লেষণাত্মক করে তুলতে বাধ্য করেছে।

একইভাবে, শিক্ষকরা AI দিয়ে পড়ানোর উপকরণ তৈরি করতে পারছেন, ডাক্তাররা রোগ নির্ণয়ে AI রিপোর্ট ব্যবহার করছেন, আইনজীবীরা AI দিয়ে কেস স্টাডি খুঁজে পাচ্ছেন। কিন্তু সিদ্ধান্ত নেওয়ার ক্ষমতা এখনো মানুষের হাতেই AI এর সবচেয়ে বড় আশীর্বাদ হলো—এটি এমন অনেক নতুন কাজ তৈরি করেছে, যেগুলোর অস্তিত্ব আগে ছিল না। যেমন — AI Engineer, Machine Learning Specialist, Data Scientist, Prompt Engineer, AI Ethics Expert, Cybersecurity Analyst, Cloud Computing Specialist, Robotics Technician, Automation Consultant| এগুলো এমন পেশা, যা আগামী দশকে আরও বেশি চাহিদাসম্পন্ন হবে। শুধু তাই নয়, AI ব্যবহার করে ছোট ব্যবসায়ী বা সাধারণ মানুষও নতুনভাবে উপার্জনের সুযোগ পাচ্ছে। যেমন— YouTube Content Creation, Freelancing, Graphic Design, Digital Marketing, Online Class| আগে এসব কাজ করতে অনেক বড় টিম বা খরচ লাগত। এখন একজন ব্যক্তি AI ব্যবহার করে একাই অনেক কাজ সম্পন্ন করতে পারে। ফলে উদ্যোক্তা হওয়া সহজ হয়েছে।একজন তরুণ যদি AI দিয়ে ভিডিও এডিটিং শেখে, স্ক্রিপ্ট লেখা শেখে, এবং মার্কেটিং বোঝে, তাহলে সে ঘরে বসেই বিশ্ববাজারে কাজ করতে পারে। অর্থাৎ AI শুধু চাকরি কমাচ্ছে না, বরং কর্মসংস্থানের নতুন দিগন্ত খুলে দিচ্ছে।

AI-এর কারণে কোন ধরনের মানুষ সবচেয়ে বেশি ক্ষতিগ্রস্ত হচ্ছে?

AI এর প্রভাবে সবচেয়ে বেশি ক্ষতিগ্রস্ত হচ্ছে সেই মানুষগুলো—যারা দীর্ঘদিন একই ধরনের কাজ করে এসেছে, যারা নতুন প্রযুক্তি শিখতে অনিচ্ছুক, যাদের কাজ পুনরাবৃত্তিমূলক এবং সহজে অটোমেট করা যায়, যারা নিজের দক্ষতা উন্নয়নে বিনিয়োগ করেন না| এটা অনেকটা এমন—যে ব্যক্তি একসময় শুধু টাইপরাইটার চালাতে জানতেন, কিন্তু কম্পিউটার শেখেননি, তিনি পরবর্তীতে পিছিয়ে পড়েছেন। AI যুগে একই ঘটনা ঘটছে। যারা নিজেকে আপডেট করছে না, তারা ধীরে ধীরে পিছিয়ে পড়ছে।

AI যুগে টিকে থাকতে হলে কী করতে হবে?

AI যুগে টিকে থাকতে হলে সবচেয়ে বড় অস্ত্র হলো দক্ষতা (Skill)। এখন ডিগ্রির চেয়ে বেশি গুরুত্বপূর্ণ হয়ে উঠেছে দক্ষতা।AI যুগে মানুষের উচিত—

১. প্রযুক্তিগত দক্ষতা বাড়ানো যেমন— বেসিক কম্পিউটার স্কিল(Basic Computer Skill), ডেটা বিশ্লেষণ(Data Analyst), ডিজিটাল মার্কেটিং (Digital Marketng), কোডিং(Coding), AI টুল ব্যবহার করা

২. মানবিক দক্ষতা (Human Skills) উন্নত করা AI যতই শক্তিশালী হোক, মানুষের কিছু দক্ষতা AI এখনো পুরোপুরি করতে পারে না। যেমন— নেতৃত্ব (Leadership) আবেগ বোঝা (Emotional Intelligence), সৃজনশীল চিন্তা (Creativity),সমস্যা সমাধান (Critical Thinking),যোগাযোগ দক্ষতা (Communication Skills),এই দক্ষতাগুলোই ভবিষ্যতের চাকরিতে মানুষকে আলাদা করবে।

৩. আজীবন শেখার মানসিকতা (Lifelong Learning)

AI যুগে শেখা থেমে গেলে পিছিয়ে পড়া নিশ্চিত। তাই নিয়মিত নতুন কোর্স, নতুন প্রযুক্তি এবং নতুন দক্ষতা শেখা জরুরি।

AI কি মানবসমাজের জন্য বিপদ? নাকি এটি একটি বিবর্তন?

AI কে অনেকেই বিপদ মনে করেন, কিন্তু ইতিহাস বলে—প্রযুক্তি মানবসভ্যতাকে ধ্বংস করেনি, বরং মানবসভ্যতাকে আরও এগিয়ে নিয়ে গেছে। যখন শিল্প বিপ্লব শুরু হয়েছিল, তখনও মানুষ ভেবেছিল মেশিন আসায় শ্রমিকরা কাজ হারাবে। সত্যিই অনেক কাজ হারিয়েছিল। কিন্তু একই সঙ্গে নতুন শিল্প, নতুন চাকরি এবং নতুন জীবনযাত্রা তৈরি হয়েছিল। AI আজ ঠিক সেই ধরনের একটি পরিবর্তন নিয়ে এসেছে।AI আসলে মানবসমাজের একটি বিবর্তন (evolution)। মানুষ যেমন কৃষি থেকে শিল্পে গেছে, শিল্প থেকে তথ্যপ্রযুক্তির যুগে এসেছে, এখন তথ্যপ্রযুক্তি থেকে AI যুগে প্রবেশ করছে।

তবে সমস্যা কোথায়?

AI যদি সুযোগ হয়, তাহলে সমস্যা কোথায়? সমস্যা হলো—এই সুযোগ সবার জন্য সমানভাবে পৌঁছাচ্ছে না। যারা শহরে থাকে, যাদের ভালো ইন্টারনেট আছে, যারা ইংরেজি জানে, যারা প্রযুক্তি শেখার সুযোগ পায়—তারা দ্রুত AI যুগের সুবিধা নিতে পারছে। কিন্তু গ্রামাঞ্চলের মানুষ, দরিদ্র পরিবার, কম শিক্ষিত জনগোষ্ঠী এই পরিবর্তনে পিছিয়ে পড়ছে। এতে সমাজে বৈষম্য বাড়ার ঝুঁকি তৈরি হচ্ছে।তাই AI যুগে সরকার, শিক্ষা প্রতিষ্ঠান এবং কোম্পানিগুলোর দায়িত্ব হলো— দক্ষতা উন্নয়নের প্রশিক্ষণ দেওয়া, প্রযুক্তিকে সবার জন্য সহজলভ্য করা, নতুন কর্মসংস্থানের ব্যবস্থা করা| কর্মীদের পুনঃপ্রশিক্ষণ (reskilling) ও দক্ষতা বৃদ্ধি (upskilling) নিশ্চিত করা|

উপসংহার:

সব দিক বিবেচনা করলে বলা যায়—AI শুধু চাকরি হারানোর কারণ নয়, বরং এটি একটি বিশাল সুযোগও। তবে এটি এমন একটি সুযোগ, যা কাজে লাগাতে হলে মানুষকে পরিবর্তনের সঙ্গে মানিয়ে নিতে হবে।

AI অনেক কাজের প্রয়োজন কমিয়ে দিচ্ছে—এটা সত্য। কিন্তু একই সঙ্গে AI নতুন ধরনের কাজ তৈরি করছে, দক্ষতার নতুন দিগন্ত খুলে দিচ্ছে, এবং মানুষের জীবনকে আরও সহজ করছে। যে ব্যক্তি সময়ের সঙ্গে তাল মিলিয়ে নিজেকে প্রস্তুত করবে, তার জন্য AI হবে আশীর্বাদ। আর যে ব্যক্তি পরিবর্তনকে অস্বীকার করবে, তার জন্য AI হবে একটি কঠিন চ্যালেঞ্জ।

অতএব, প্রশ্ন হওয়া উচিত— "**AI চাকরি কেড়ে নিচ্ছে কি?**" নয়। বরং প্রশ্ন হওয়া উচিত— "**AI যুগে আমি কীভাবে নিজেকে দক্ষ করে তুলব?**"কারণ ভবিষ্যৎ তাদেরই, যারা প্রযুক্তিকে ভয় পায় না, বরং প্রযুক্তিকে ব্যবহার করতে জানে। AI মানুষের শত্রু নয়—AI মানুষের হাতে একটি শক্তিশালী হাতিয়ার। আর হাতিয়ার দিয়ে ধ্বংসও করা যায়, উন্নয়নও করা যায়। সিদ্ধান্তটা শেষ পর্যন্ত মানুষেরই।

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DIGITAL ADDICTION & MENTAL HEALTH IN THE AGE OF TECHNOLOGY

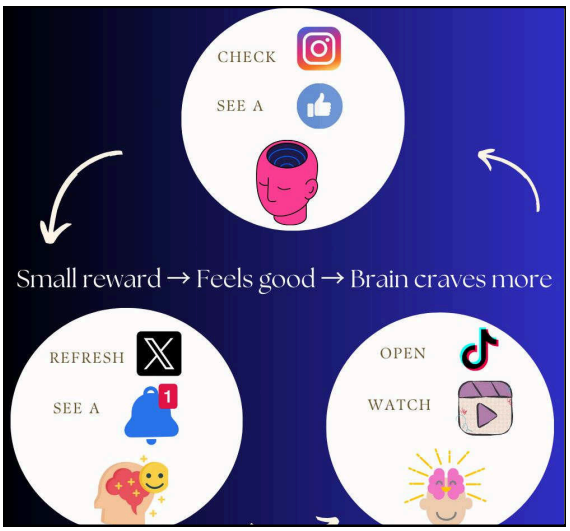
Introduction

In the modern era, technology has become deeply embedded in our daily lives. From smartphones and laptops to social media and streaming platforms, digital devices are now essential tools for communication, education, and entertainment. For college students especially, technology plays a crucial role in academics and social interaction. However, alongside its benefits, a new concern has emerged—digital addiction.

Digital addiction refers to the excessive and uncontrolled use of digital devices, leading to negative effects on mental, emotional, and social well-being. While technology has simplified life, overdependence on it is gradually affecting mental health, attention span, and productivity. Understanding this issue is essential for maintaining a balanced and healthy lifestyle.

The Growing Dependence on Digital Devices

Over the past decade, the use of smartphones and the internet has increased rapidly. Students spend hours scrolling through social media, watching videos, playing games, or chatting online. What starts as a simple habit often turns into a daily routine that is hard to break. Many applications are designed to keep users engaged. Features like notifications, likes, comments, and endless scrolling create a cycle where users continuously check their devices.



This leads to a strong psychological urge to stay connected at all times. For students, this habit often interferes with studies, sleep, and real-life interactions.

Effects on Mental Health

One of the most significant impacts of digital addiction is on mental health. Constant exposure to social media can lead to anxiety and stress. Students often compare their lives with others, which creates unrealistic expectations and lowers self-confidence.

Another serious issue is depression. Spending too much time online reduces face-to-

face communication, leading to feelings of loneliness and isolation. Even though people are virtually connected, they may feel emotionally disconnected in real life.

Sleep disturbance is also a common problem. Many students use their phones late at night, which affects their sleep cycle. The blue light from screens reduces melatonin production, making it harder to fall asleep. Poor sleep can result in fatigue, lack of concentration, and mood swings.

Impact on Academic Performance

Digital addiction directly affects academic life. Students who spend excessive time on their devices often struggle to concentrate on studies. They are easily distracted by notifications and social media updates.

Procrastination becomes a major issue. Instead of completing assignments on time, students delay their work and end up rushing at the last moment. This not only reduces the quality of their work but also increases stress levels.

Moreover, multitasking—such as studying while using social media—reduces efficiency. It becomes difficult to retain information, and learning becomes less effective. As a result, academic performance may decline over time.

Changes in Social Behavior

Digital addiction also affects social behavior. Students may prefer online communication over real-life interaction. This reduces their ability to build strong relationships and communicate effectively.

Face-to-face conversations involve emotions, expressions, and body language, which are often missing in digital communication. Over time, this can weaken interpersonal skills.

Additionally, excessive screen time can cause irritability and mood changes. When individuals are unable to access their devices, they may feel restless or frustrated. This behavior is similar to withdrawal symptoms seen in other forms of addiction.

The Role of Technology Design

It is important to understand that digital addiction is not entirely accidental. Many digital platforms are intentionally designed to keep users engaged. Algorithms analyze user behavior and show content that matches their interests, making it difficult to stop scrolling.

Features like auto play videos, notifications, and reward systems (likes, shares) create a sense of satisfaction and encourage repeated usage. This design increases screen time and strengthens addictive behavior.

Being aware of these mechanisms can help individuals take control of their digital habits.

Positive Use of Technology

Despite its negative effects, technology is not harmful when used wisely. It has transformed education by providing access to online resources, e-books, and learning

platforms. Students can attend virtual classes, collaborate with peers, and gain knowledge from anywhere in the world.

Technology also supports mental health through apps for meditation, stress management, and counseling. It enables people to stay connected with family and friends, especially during difficult times.

The key is to maintain a balance between productive use and excessive use.

Solutions to Overcome Digital Addiction

Overcoming digital addiction requires self-awareness and discipline. One effective method is setting limits on screen time. Many devices offer features to monitor and control usage.

Creating a daily routine can help reduce unnecessary device use. Allocating specific time for studying, relaxation, and digital activities ensures better time management.

Engaging in offline activities is equally important. Physical exercise, reading, hobbies, and spending time with friends can reduce dependence on digital devices.

Another helpful strategy is practicing digital detox, where individuals take a break from screens for a certain period. This helps refresh the mind and improve focus.

Role of Educational Institutions

Colleges and universities can play a major role in addressing digital addiction. Awareness programs and workshops can educate students about its impact on mental health.

Institutions can encourage participation in sports, cultural activities, and group discussions to promote real-life interaction. Counseling services should also be available for students facing mental health challenges.

By creating a balanced environment, institutions can help students develop healthy digital habits.

Conclusion

Digital addiction is a growing concern in today's technology-driven world. While digital devices offer numerous benefits, their excessive use can negatively affect mental health, academic performance, and social life.

The solution is not to avoid technology but to use it responsibly. By maintaining a balance between online and offline life, students can enjoy the advantages of technology without harming their well-being.

As future professionals and engineers, it is important to understand both the power and the impact of technology. A mindful approach toward its use will ensure a healthier and more productive future.

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FUTURE OVERVIEW ON ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC) INDUSTRY IN INDIA

DEFINITION OF EPC INDUSTRY-

EPC stands for Engineering, Procurement, and Construction. It is a project delivery model that gives contractors the responsibility of handling a project from start to finish.EPC contractors will handle the project in its entirety, from the initial design and engineering plans to construction and completion. This approach to project management is also referred to as a "lump sum turnkey (LSTK)" approach.

EPC IMPORTANCE IN SETOR LIKE POWER, OIL AND GAS, TRANSPORT AND URBAN INFRASTRUCTURE-

Oil & Gas: EPC is vital for constructing complex, high-stakes infrastructure like refineries, LNG plants, and pipelines. Because these projects often cost billions, EPC contractors ensure safety, operational reliability, and environmental compliance, reducing the risk of costly rework.

Power: In renewable energy (solar, wind) and traditional power generation, EPC contractors provide complete project delivery—from site assessment to final commissioning. They are crucial for grid resilience and integrating complex components within rigid timelines.

Transport: For highways, bridges, and railways, EPC models ensure faster, standardized construction. They are especially important for projects that require coordinating with existing infrastructure while minimizing public disruption.

Urban Infrastructure: EPC is foundational for building smart cities, modern water treatment facilities, and urban transit systems. They enable the integration of IoT and smart technologies into urban infrastructure.

GROWTH OF EPC INDUSTRY IN INDIA-

India's Engineering, Procurement, and Construction (EPC) industry is experiencing rapid growth, projected to rise from USD 69.28 billion in to over USD 126 billion in 2030, growing at a CAGR of 12.87%, Driven by massive infrastructure investments like the National Infrastructure Pipeline ($1.4 trillion), it is a major employment generator expected to create 25 million new jobs by 2030.

Infrastructure Push: Huge government capital expenditures (INR 11.11 lakh crore for FY25) toward highways, railways, and metro projects.

Renewable Energy Focus: The push for 500 GW of non-fossil capacity by 2030 has made solar and wind EPC a high-growth area.

Industrial & Urban Development: Expansion of industrial corridors, data centers, and smart city projects drives demand for advanced construction.

Technology Adoption: Mandatory adoption of BIM (Building Information Modelling) and digital twins in public tenders is improving efficiency and power quality.

REVENUE OF EPC INDUSTRY IN INDIA-

Large, diversified Indian EPC companies are projected to see revenue growth of 9–11% in FY26, driven by a 7–9% increase in infrastructure capital expenditure (capex), strong order books (3.7x book-to-revenue), and faster project execution. This moderate growth follows an 8.3% rise in FY25, following a high-growth phase (20% CAGR) between FY 2022-24.

Infrastructure Capex: Sustained, strong central/state budgetary allocations, with private sector participation in infrastructure expected to rise to 11% in FY26.

Order Book Strength: The order book-to-revenue ratio for large EPC firms stands strong at 3.7 times as of March 2024.

Sectoral Shift: Power transmission/distribution, roads, and urban development projects are driving revenue, with power projects increasingly supporting operating margins.

Overseas Expansion: Increased focus on overseas projects (27% of order books as of March 2024) offers faster execution and improved profitability, rising from 23% in 2024.

Profitability: Operating margins are expected to improve to 9.5% for major players, aided by stable commodity prices and better order mix.

KEY EPC PLAYERS IN INDIA-

Larsen & Toubro (L&T): India's largest construction and engineering company with massive operations in infrastructure.

Tata Projects Ltd: Major player in urban infrastructure, power, and industrial turnkey projects.

Shapoorji Pallonji & Co. Ltd (SPCL): Renowned for industrial, commercial, and high-rise construction.

Afcons Infrastructure: Specializes in marine, bridges, and complex infrastructure projects.

Engineers India Limited (EIL): Leading public sector undertaking specializing in oil & gas and petrochemicals.

IRCON International Ltd: Prominent in railway and highway infrastructure.

ROLE OF GOVERNMENT POLICIES IN EPC-

Driving Infrastructure Demand: Initiatives such as the National Infrastructure Pipeline (NIP) provide a roadmap for massive investments in transport, energy, and urban

development, driving demand for EPC services.

Funding and Risk Management: EPC contracts are predominantly funded by the government, which assumes risks related to land acquisition, environmental clearances, and policy changes, allowing contractors to focus on design and construction. Policy Support for "Make in India": Policies such as Purchase Preference (linked with LocalContent) or PP-LC encourage the use of local goods and services in projects, specifically within Public Sector Undertakings (PSUs).

1.CHALLANGES-

EPC projects face significant challanges including cost overruns due to material price volatility, project delays from supply chain disruptions, and complex regulatory compliance.

CONCLUSION- The future of the EPC (Engineering, Procurement, and Construction) industry in India appears highly promising, driven by strong government initiatives, rapid infrastructure development, and increasing investments in sectors such as energy, transportation, and urban development. Programs focused on renewable energy, smart cities, and industrial expansion are expected to create sustained demand for EPC services. However, the industry must address challenges such as project delays, cost overruns, regulatory complexities, and the need for technological adoption. Companies that embrace digitalization, efficient project management practices, and sustainable solutions will be better positioned to capitalize on emerging opportunities. Overall, the EPC sector is set to play a crucial role in shaping India's economic growth and infrastructure landscape in the coming years.

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MY FIRST YEAR - A JOURNEY TO REMEMBER

Sometimes, the most unforgettable journeys begin with a single step into the unknown. For me, that step was taken on 17th October 2022, the day I arrived at my hostel for the very first time. Everything felt new the room, the surroundings, and the people around me. At first, everyone was a stranger, but it didn't take long for conversations to begin and friendships to grow.

Very soon, hostel life became one of the most beautiful parts of my college journey. Late-night conversations on endless topics, playing carrom, watching late-night movies, and celebrating each other's birthdays turned ordinary days into unforgettable memories. We ate together, woke up together, and spent hours just sitting and talking. Those moments were simple, yet they brought immense happiness. Looking back now, I often smile and think, what wonderful days those were.

One of the most special memories of hostel life was Saraswati Puja. All the students came together and managed everything ourselves like arranging decorations and buying the puja materials. Everyone contributed in their own way, and the entire celebration felt like a big family working together. The joy, unity, and excitement of that day made it truly unforgettable.

Hostel life teaches lessons that no classroom can teach. It teaches independence, responsibility, and how to appreciate the small moments of life. Living with friends, sharing laughter, supporting each other, and finding happiness in the simplest things made hostel life truly unique. Even today, I deeply miss those beautiful days.

The very next day, on 18th October 2022, my college journey officially began. It was my first day stepping into college life, filled with excitement, curiosity, and a little nervousness. As I walked into my classroom, everything around me felt new, the environment, the unfamiliar faces, and the experiences waiting ahead.

At first, everyone in the class was a stranger. But slowly, conversations began and interactions grew. Day by day, we started knowing each other better, and those strangers soon became friends.

One by one, our classes began, and we met our teachers for the first time. Each teacher had their

own unique style of teaching, but what stood out the most was how supportive, friendly, and encouraging they were. Their guidance helped us feel comfortable and confident as we stepped into this new phase of life.

Soon, college became part of our daily routine. Every morning students would arrive early, chatting and laughing before the classes began. We attended lectures, shared notes, helped each other, and created countless small memories. The best part of the day was spending time with friends talking, joking, and enjoying every moment together. By evening, we would leave the campus with smiles and laughter, already looking forward to the next day.

One of the most exciting highlights of our first year was the Tech Fest, where I participated in Omegatrix and Robotics. It was an amazing experience that allowed us to explore technology, learn new skills, and feel the vibrant energy of college events.

Just about a week later came the much-awaited Cultural Fest, held on a Sunday. The entire campus was filled with excitement and celebration. There were dance performances, music, delicious food, and endless fun. One of the most memorable moments was the live performance by Nakash Aziz, which made the evening even more special. The night became even more energetic with the DJ performance by DJ Azfar Aziz, filling the campus with music, excitement, and celebration.

People often say that the first year of college is the most special because everything feels new. I truly experienced that feeling. Meeting people with different personalities, ideas, and dreams made college life even more vibrant and meaningful.

After college hours, many of us would often go together to CC2, spending time talking, laughing, and enjoying each other's company. Those simple outings turned into some of the most cherished memories of our first year.

Between classes, practicals, assignments, and exams, time passed surprisingly fast. Before we even realized it, the first year was already coming to an end. Looking back, it feels like a journey filled with learning, friendship, laughter, and unforgettable experiences.

My first year in college was not just about academics, it was about discovering new experiences, building friendships, and creating memories that will stay with me forever.

And when I look back at those days, I realize something beautiful:

the first year was not just the beginning of college life, it was the beginning of friendships, lessons, and memories that will stay in my heart for a lifetime.

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RECENT TRENDS OF POWER ELECTRONICS IN SOLAR POWER SYSTEMS

With the increasing emissions of greenhouse gases & other pollutants which lead to global warming the demand for renewable energy sources has been increased. There are many renewable energy sources such as Solar, wind, biomass, mini-hydro & tidal power etc. Power Electronics finds its applications in most of the Renewable energy sources technologies. It plays an important role on controlling as well as interfacing the renewable system with both the grid & standalone applications. So more and more emphasis is given on the design & control of Power Converters.

The whole world is focusing on the utilisation of renewable energy sources (RES) in order to minimise the world power crisis. The total power generation of RES is continuously increasing & is going to be tripled within the next few decades. So introduce more renewable energies such as Solar photovoltaic (SPV), Wind Power, biomass power, tidal power. The power from these RES are to be integrated into the electric grid. Among different RES wind turbine systems (WTS) & solar photo voltaic (SPV) technologies are the mostly used technologies for a large portion of renewable energy generation.

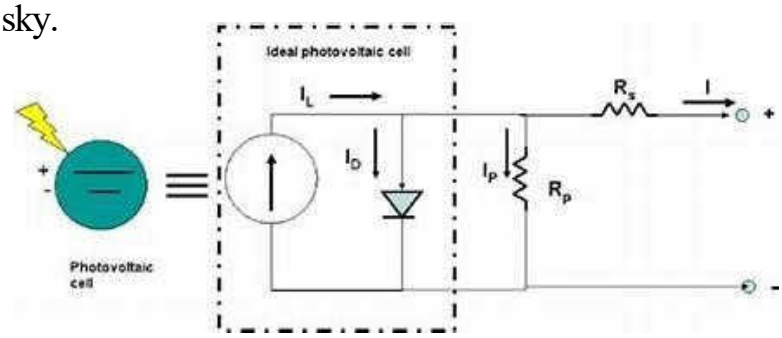
By the year 2023, it is estimated to get 227 GW of energy from the renewable sources, which was 175 GW earlier. It is estimated to get 113 GW through the solar power,66 GW from the wind power, 10 GW from the biomass power, 5 GW from the small hydro & 31 GW from the floating solar and offshore wind power. So more and more emphasis is given on the renewable energy sources.

Solar energy

The earth receives the energy from the Sun in the form of electromagnetic radiations. Solar power is the conversion of energy from sunlight into electricity, directly using Photo voltaic (PV), indirectly using concentrated Solar Power or a combination of both. Concentrated Solar Power system uses lenses or mirrors & tracking system to focus a large area of sunlight into a small beam. In solar photovoltaic system the energy is directly converted into electrical energy.

The device which converts the solar energy into the electrical energy is called solar cell. A large number of solar cells are connected in series and parallel to get the suitable voltage.

Photovoltaic tracking systems are provided with the tracking mechanisms to follow the sun as it moves through the sky.



POWER ELECTRONICS (PE)

Power Electronics is the application of solid state Electronics to the control & conversion of Electric power. The power conversion systems can be classified according to the type of input and output power.

- AC to DC rectifier
- DC to AC inverter
- DC to DC (DC to DC converter)
- AC to AC (AC to AC converter)

The Role of Power Electronics in Solar Energy

Power Electronics uses the power semiconductor devices to perform the switching action in order to achieve a desired conversion strategy. PE acts as an interface between the PV system & the utility grid. A PV system connected to grid consists of a PV array, DC-DC converter, DC-AC converter & a controller stage followed by utility grid.

1. Photovoltaic Solar Cell

The solar cell can be connected in series & parallel incorporated in a module. Several modules may be interconnected to comprise a solar array.

1. Types of PV systems:

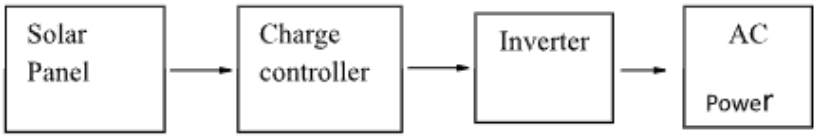
There are two types of solar photovoltaic system.

i) Autonomous Solar Photovoltaic system/ Standalone solar photovoltaic system

ii) Grid connected solar photovoltaic system

i) Autonomous Solar Photovoltaic system/ Standalone solar photovoltaic system:

A standalone SPV is one which is not connected to the power grid. A standalone PV system usually has a provision for energy storage. This system has battery support to supply the load requirement during the night hours or when the sunshine is inadequate during the day.



ii) Grid connected solar photo voltaic system:

The grid connected SPV systems inject power and energy directly to the utility grid.

There are two types of grid connected system.

1. Without battery
2. With battery

In off –grid systems, there is the need to use DC voltage & current with stable characteristics, independent from the irradiance fluctuations. So, the DC-DC converter or a DC chopper is a static device used to obtain variable DC voltage from a source of constant DC voltage.

Switch mode DC-DC converters are used to match the DC output of a PV generator to a variable load.

Three different topologies are mostly used.

1. Step up converter
2. Step down converter
3. Step up and Step down converter

Three different topologies are mostly used.

i) Step-up Converter(Boost Converter): The converters which can be used to produce higher voltages at the output than the input voltage is called the step-up converter

ii) Step down Converter (Buck Converter):

The converters which can be used to produce reduced voltage at the output than the input voltage is called the step-down converter.

iii)Step up and step down Converter(Buck-Boost Converter)

A chopper can also be used in both step-up & step-down modes by continuously varying its duty cycle.

Inverter Configuration:

The DC to AC power converters are known as inverters. An inverter is a circuit which converts a DC power into an AC power at desired output voltage & frequency. The DC Power input to the inverter may be battery, fuel cell, solar cells or other DC source.

Different PV inverter configuration

In off-grid systems stand alone self commutated inverters producing AC current without synchronisation with a reference signal are used. These inverters have the responsibility to produce AC voltage & current characteristics (sinusoidal 230V/50Hz) same as those of a typical grid in order to supply off-grid loads.

Different PV inverter topologies

1. Single-phase Half bridge voltage source inverters
2. Single-phase Full bridge voltage source inverters
3. Three Phase Inverter

In grid connected applications the energy is provided directly to the grid and the necessary parts are the PV modules & the inverters. This reduces the cost of the system & it also reduces the necessary maintenances as the batteries are the most maintenance demanding components. The inverters for grid connected applications may have different topologies & operation than off-grid ones. They have to produce excellent quality sine wave output, follow the frequency & voltage of the grid and extract maximum power from the PV modules through the maximum Power Point Tracker(MPPT).

The inverter input scans the I-V characteristics of the string until the maximum power point is found. The grid inverter always monitors the grid and the output voltage & the output voltage & frequency must be controlled. Grid connected inverters are classified as voltage Source Inverters (VSI) & Current Source Inverters(CSI).

The I-V characteristics of the pv string is scanned by the inverter until the maximum power point is found. The grid inverter always monitors the grid voltage and the output voltage. The output voltage & frequency must be controlled.

Maximum Power Point Tracker (MPPT)

Maximum Power Point Tracker(MPPT) is an electronic system which operates the photovoltaic module in a manner so that it can extract the maximum power from the system.

Generally, MPPT is installed in between PV system and the load connected to the system. Coupling of load for maximum power may require either lower current at higher voltage or a lower voltage at higher current.

Different methods are there for MPPT

1. Perturbation and Observation technique
2. Incremental Conductance technique
3. Current Sweep
4. Constant Voltage

In this article, Recent Trends of Power Electronics for solar Power systems used in PV applications are presented. Due to the high demand for renewable energy sources applications, there is continuing research for improving the total efficiency of these applications and by improving each electronic part included. As far as PV systems are concerned, inverter efficiency is continuously improving, and ways to minimise device weight are being tested to reduce transportation costs and ease installation. Moreover, the power and voltage range of the string and central inverters is increased, so that more efficient and cheaper PV installations can be realised using a relatively low number of inverters.

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Words fall empty, before they ever reach you

A heart full of emotions with nowhere to land,
a buffer overflowing with unsent data.
You stayed close enough to touch,
yet always beyond my communication range
a connection visible, but never accessible.
You lived in a space where distance had no units,
where feelings decayed before they could start.
I stored galaxies of words for you,
but each packet vanished in transmission–
lost to memories you'd already powered down.
Maybe we were never coded for
a eachother,
only the low-noise stability of friendship.
A system with fewer error, fewer losses,
something steady enough to endure
even what my heart couldn't say.
So I offload the data my voice
can't carry,
clearing you gently from my core memory.
If my soul ever reaches your network again,
it will be just a fading signal–

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WHERE THEORY MEETS TURBINES: A GLIMPSE INTO MY TRAINING AT NTPC BARH

Standing in front of a 660 MW generator for the first time, I realized that engineering is not just about understanding systems but about witnessing them in action. This moment captured the essence of my vocational training at NTPC Limited Barh Super Thermal Power Station, where classroom concepts transformed into real-world applications.

NTPC Barh, located in Bihar, is one of India's largest supercritical thermal power plants with an installed capacity of 3300 MW. From the outset, the scale, discipline, and systematic functioning of the plant were striking. The environment reflected a perfect balance of advanced technology and operational precision, setting a strong foundation for learning.

The training began with a detailed safety induction, emphasizing the importance of personal protective equipment and adherence to strict safety protocols. This highlighted a key lesson for working in high-voltage and high-temperature environments requires not only technical knowledge but also a deep sense of responsibility. As we explored different sections of the plant, the complete process of power generation became clearer. The coal handling system demonstrated how raw coal is transported, crushed, and prepared for combustion. In the boiler section, water is converted into high-pressure, high-temperature steam using supercritical technology. This steam then drives the turbine, initiating the core process of energy conversion.

The turbine and generator area was particularly impactful. Observing the high-speed rotation of

the turbine and its coupling with the generator provided a clear understanding of how mechanical energy is converted into electrical energy on a large scale. Sharing this experience with my teammate, Sougata Roy Chowdhury, made the learning process more engaging, as we discussed observations and connected theoretical concepts with real operations.

Another important aspect of the training was the control room, where advanced systems monitor and regulate plant performance. Engineers continuously track parameters such as temperature, pressure, and flow rates to ensure efficiency and safety. This exposure highlighted the role of automation and real-time monitoring in modern power plants.

We also examined auxiliary systems such as cooling towers, condensers, and the switchyard. The cooling system illustrated how excess heat is managed, while the switchyard demonstrated how generated electricity is transmitted to the grid. These systems reinforced the idea that every component plays a vital role in maintaining overall efficiency and reliability. Beyond technical knowledge, the training offered insights into professional work culture. Interactions with engineers emphasized the importance of teamwork, discipline, and problem-solving in industrial environments. It also provided a clearer perspective on the responsibilities associated with large-scale power generation.

In conclusion, my training at NTPC Barh was a meaningful learning experience that bridged the gap between theory and practice. It strengthened my technical understanding while also shaping my professional outlook. This exposure has not only enhanced my knowledge but has also prepared me to approach engineering challenges with greater confidence and clarity.

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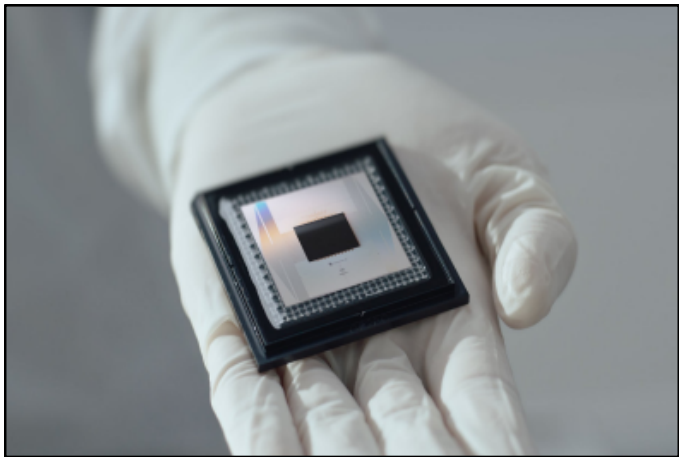
WILLOW QUANTUM CHIP: THE COLDEST, FASTEST BREAKTHROUGH IN HUMAN HISTORY



Inside a quiet, zen-like laboratory in Santa Barbara, California, a silver cylinder suspended from the ceiling hums with a faint, rhythmic pulse.1 Inside this "cryostat," shielded by layers of superconductive aluminum and nickel-iron alloys, sits the Willow quantum chip—a device operating at 10 millikelvins, a temperature colder than the furthest reaches of outer space.1

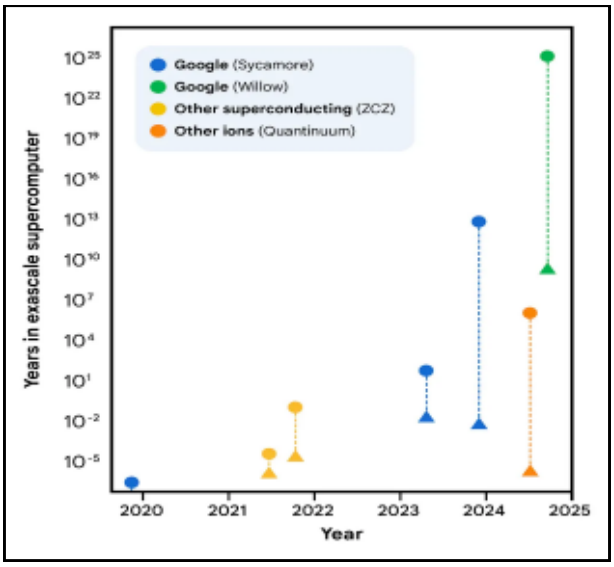
Unveiled in December 2024, the Willow processor isn't just another incremental update in the tech world. It represents a "split-the-atom" moment for computing. With 105 superconducting qubits, Willow has achieved what many physicists thought might be decades away: a system that actually gets more accurate as it gets larger.4

The 10 Septillion Year Sprint

To understand why the Willow quantum chip has the scientific community buzzing, look no further than its first major test. In a benchmark known as Random Circuit Sampling, Willow completed a calculation in under five minutes. To put that in perspective, Google's team estimated that the Frontier supercomputer—currently one of the fastest exascale machines on Earth—would need approximately 10 septillion years to do the same.

If you were to write that number out, it's 10 followed by 24 zeros: .4 It is a span of time that vastly exceeds the age of the universe itself. While these random math problems don't have a direct "real-world" use yet, they prove a staggering point: Willow has officially entered a

regime of "quantum supremacy" that classical machines can no longer even see in their rearview mirrors.



Cracking the "Error Code"

The real genius of Willow, however, isn't just its speed—it's its resilience. For thirty years, the "dragon" of quantum computing has been noise.7 Qubits are notoriously fragile; even a stray photon or a tiny change in temperature can cause them to lose their "quantumness," leading to errors in calculation.

Typically, the more qubits you add to a system, the more errors you get. Willow broke that rule.4 By using a technique called "surface code" error correction, the Google team demonstrated "below-threshold" performance. They grouped physical qubits together into "logical qubits" and found that as they increased the size of the grid—from 3x3 to 5x5 and finally to 7x7—the error rate actually dropped.

This is the "unfakeable sign" the industry has been waiting for. It proves that as we build bigger quantum computers, they won't just be faster; they will be more reliable. The qubits on Willow can now hold onto their information (known as coherence time) for nearly 100 microseconds a 5x improvement over the 2019 Sycamore chip.

Feature	Sycamore (2019)	Willow (2024)
Qubit Count	53	105
Benchmark Time	~200 Seconds	Under 5 Minutes
Classical Equivalent	10,000 Years	10^25 Years

Beyond the Benchmark: The "Quantum-Scope"

While the 10-septillion-year calculation proved the hardware's power, a newer breakthrough in late 2024 showed its practical potential. In partnership with UC Berkeley, researchers ran the "Quantum Echoes" algorithm on the Willow chip.

Think of this algorithm like a "quantum-scope" or a molecular ruler.12 By purposefully perturbing a qubit and then reversing the calculation to listen for the "echo," researchers were able to measure the 3D geometry of organic molecules with 15 and 28 atoms.12 Willow performed this task 13,000 times faster than the best known classical algorithms.

This move from abstract math to molecular biology is a game-changer. It suggests that the Willow generation of chips could soon be used as a "molecular microscope," helping scientists design new medicines, more efficient batteries for electric cars, or even better materials for carbon capture.

The Road to One Million

Google isn't stopping at 105 qubits. The Willow quantum chip is a critical milestone on a roadmap that ends in 2029 with a "useful, large-scale quantum computer" consisting of one million physical qubits.19

The challenge ahead is immense. Reaching a million qubits will require building massive 2D arrays of hardware and perfecting real-time error correction so that a machine can run for days or weeks without a single crash.19 But with Willow, the "physics" of the problem is solved; now, it is simply a matter of engineering.

We are no longer asking if a quantum computer can outperform a supercomputer. We are now asking what we will discover first when the era of the "quantum-scope" truly begins.

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CHATGPT: REVOLUTIONIZING HUMAN-COMPUTER INTERACTION

तद्विद्धि प्रणिपातेन परिप्रश्नेन सेवया। उपदेक्ष्यन्ति ते ज्ञानं ज्ञानिनस्तत्त्वदर्शिनः

॥ अध्यायः ४ ३४
Tad viddhi pranipatena
Pariprashnena sevaya
Upadekshyanti te jnanam
Jnaninastattva darshinah

In the Srimad Bhagavad Gita, the above verse no. 34 of Chapter 4 (Jnana Yoga) was mentioned by Sri Krishna for Arjuna. It means - "Learn the Truth by approaching a spiritual master. Inquire from him with reverence and render service unto him. Such an enlightened Saint can impart knowledge unto you because he has seen the Truth."

In today's digital world ChatGPT is such a master which can teach us any subject and assist us on everything, which is available in the internet.

In the rapidly evolving landscape of artificial intelligence (AI), one innovation has stood out for its ability to bridge the gap between human communication and machine understanding—ChatGPT. Developed by OpenAI, ChatGPT is a conversational AI model based on the Generative Pre-trained Transformer (GPT) architecture. It is designed to understand and generate human-like text, enabling it to participate in meaningful dialogue, assist with tasks, and provide information on a wide range of topics. Its emergence represents a significant shift in how we interact with machines and access knowledge.

ChatGPT is a product of years of research in natural language processing (NLP). It builds upon the GPT series of language models, with GPT-4 being the most advanced version available as of its release. These models are trained on vast amounts of text data from the internet, allowing them to learn grammar, facts, reasoning abilities, and even nuances of tone and emotion. Unlike traditional chatbots with limited, rule-based responses, ChatGPT uses deep learning to understand context and generate flexible, relevant answers.

The versatility of ChatGPT has led to its adoption in numerous fields. In education, students use it to clarify concepts, draft essays, and study more effectively. In business, it powers customer

service bots, helps generate marketing content, and even supports coding and data analysis. Writers use ChatGPT as a brainstorming partner, and developers integrate it into software to enhance user experiences. Its ability to converse naturally makes it a valuable tool for both productivity and creativity.

One of the most compelling features of ChatGPT is its ability to simulate human conversation. It can understand complex questions, follow up on previous responses, and tailor its answers to the user's tone or intent. It operates 24/7, responds instantly, and can scale to serve millions of users simultaneously. Moreover, it learns from user feedback, which helps improve its accuracy and relevance over time.

ChatGPT also democratizes access to information. Anyone with an internet connection can engage with it to learn new topics, practice languages, solve technical problems, or simply have a conversation. Its accessibility and ease of use have made AI technology more approachable to the general public.

Despite its strengths, ChatGPT is not without flaws. It can sometimes produce incorrect or misleading information, especially if the query requires up-to-date or specialized knowledge. It may also reflect biases present in its training data, and it lacks a true understanding of the world, operating purely based on patterns in text rather than genuine comprehension. Furthermore, ethical concerns have arisen around privacy, misinformation, and the potential misuse of AI-generated content.

To address these issues, developers and researchers continue to refine the model, implement safety features, and explore ways to ensure responsible use. Transparency, user education, and strong moderation policies are crucial in minimizing risks.

ChatGPT represents a significant milestone in the journey toward more natural and intelligent human-computer interaction.As AI continues to improve, future versions are expected to be even more accurate, reliable,and capable of understanding multimodal inputs like images and audio. This evolution could revolutionize sectors such as healthcare, education, and entertainment, further integrating AI into our daily lives.

However, this progress must be guided by ethical principles and societal dialogue. Balancing innovation with responsibility will be key to ensuring that AI like ChatGPT benefits humanity as a whole.

ChatGPT is more than just a chatbot—it is a window into the potential of AI to augment human capabilities. By making information more accessible and interaction more intuitive, it has reshaped how we think about communication, learning, and problem-solving. While challenges remain, its continued development signals a future where intelligent systems work alongside humans to enhance understanding, creativity, and connection.

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CURRENTS OF CONNECTION: A 15-DAY ODYSSEY AT DVC ANDAL

When we boarded the train from Kolkata on the morning of June 7th, 2024, my four friends and I, students from B.P. Poddar Institute of Management and Technology, were ready for a deep dive into power generation. We were headed to the Damodar Valley Corporation (DVC) in Andal, Durgapur. However, as the train moved along, we had no idea that the "extra days" we planned for logistics would spark a lifelong friendship.

The journey was not just about moving from one city to another. It was about shifting from a closed group of classmates to being part of a broader, vibrant community.

The Unexpected Intersection

The story truly began at the station near Andal. The friends I have gone with are Rajdeep, Supriyo and Srijit. As we gathered our bags, we met four other students: Shiladitya, Subham, Tuhin, and Sudipan , They were from Meghnad Saha Institute of Technology. In engineering, there is an unspoken bond formed by shared struggles and late-night assignments. Instead of a polite nod between rival colleges, we quickly connected.

Finding a place to stay in a new city can be tough, but with eight of us instead of four, it became an adventure. We eventually found a house that became our sanctuary for the next two weeks. In that shared space, we stopped being "B.P. Poddar guys" and "Meghnad Saha guys." We were just eight students sharing a roof, meals, and a vision for the future.

Inside the Steel Giant: A Masterclass in Engineering

The DVC Andal thermal power plant is vast and impressive. For an electrical engineering student, entering those gates feels like stepping into a living textbook. Over our 15 days there, the theoretical concepts we studied in Kolkata came to life in a big way.

Together, we explored the entire energy lifecycle. We stood by the Boiler and the Furnace, feeling the intense heat that powers the plant. We admired the Steam Turbines and Generators (Alternators), grasping how mechanical rotation and electrical flow work together. Every part—from the Condenser and Cooling Towers to the Economizer, Superheater, and Reheater—

was a piece of the puzzle we put together as a team. We climbed to see the Air Preheater and looked up at the towering Chimney (Stack), while the gritty Coal Handling Plant and the efficient Ash Handling System made us aware of the huge logistics needed to power a nation. Our learning was collaborative. We stood near the Feedwater Pumps, discussing the efficiency of the cycle, helping each other understand what our textbooks didn't capture.

The Wholesome After-Hours

If the mornings focused on turbines, the evenings highlighted human connection. Back at our shared house, the atmosphere buzzed—not with high voltage, but with laughter.

We cooked together, trying new foods and local flavors from Durgapur. These shared meals were the backdrop for genuine moments where we compared notes about our different college lives, acknowledged our professors' quirks, and realized our dreams were surprisingly alike. When we weren't discussing the plant, we engaged in fierce competitions in cards and various indoor games.

A highlight of the trip was a holiday break at the Maithon Dam. For a few hours, the industrial noise faded away, replaced by the calming sound of water. We stood by the reservoir as carefree college students, taking photos and enjoying the breeze, temporarily forgetting about the complexities of the Rankine cycle to simply appreciate a sunset.

A Bittersweet Departure

By June 24th, 2024, our 15-day experience came to an end. We had arrived as strangers but left as a close-knit group. The "extra days" spent finding a place to stay turned out to be the best mistake of the trip, as they helped us form a bond that felt like it had existed for years.

Saying goodbye to Shiladitya, Subham, Tuhin, and Sudipan was tougher than we expected. We started this journey to learn about power generation but ended it realizing that the most lasting energy comes from the people around you. As we headed back to Kolkata, we took more than just a certificate; we took memories of a house filled with laughter, a dam with stunning views, and a friendship that proved that while colleges may have different names, the spirit of a student is universal.

DVC Andal provided us with technical knowledge, but the journey gave us brothers. In the grand scope of engineering life, that is the most valuable outcome of all.

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NOT JUST A DEGREE

We walked in as strangers with oversized dreams
and under slept eyes from entrance-exam nights.
First year felt like a blur of new corridors,
awkward introductions, and futures too big for our pockets.
We didn't know then
these walls were quietly memorizing our laughter.

Assignments, internal marks, panic before vivas
we complained like it was the end of the world.
We fought over group projects, over silly misunderstandings,
over who didn't reply in the class group.
Back then it felt dramatic, almost permanent.
Now it feels like scenes from a comfort film we'd replay
forever.

Canteen tables became confession rooms.
Library benches witnessed silent breakdowns and louder
jokes.
Fest nights made us feel infinite;
results day made us question everything.
Some friendships cracked, some turned unbreakable
but every moment stitched us into who we are now.

Somewhere between first attendance and final submissions,
we grew up.
Not loudly, not all at once
but in tiny shifts: in responsibility, in resilience,
in learning that failure doesn't end stories,
it edits them.

And now the calendar moves faster than our hearts can accept.
The word "farewell" sits heavy in conversations.
'We count "lasts" without wanting to
last lab, last lecture, last walk through the gate.
1t's strange how we begged for this day to come,
and now we wish it would slow down.

One day, years from now,
we will laugh at the fights that once felt unbearable.
'We will miss the chaos we once complained about.
And maybe, in some quiet moment,
we will close our eyes and return here
to this almost-ending that was actually a beginning.

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THE 2.1 KILOMETER ECHO: HOW A LUNAR SILENCE REWROTE INDIA'S DESTINY

Human ambition has always been reflected in the Moon, which mirrors our aspirations, technological prowess, and sometimes our most vulnerable moments. For over a billion people, that mirror seemed to dim in the early hours of September 7, 2019. For 48 days, India guided the Chandrayaan-2 spacecraft across a 3.84-lakh-kilometre cosmic bridge, moving in perfect rhythm with a master clock. We stood on the brink of becoming the first nation to attempt a landing near the lunar South Pole and the fourth to achieve a soft landing on the Moon.

Fig. 1:

However, a silent fault prevented the Vikram lander from reaching the cratered expanse. The signal disappeared at precisely 2.1 kilometres above the ground, less than a morning jog. There had been a tragic, static-filled stillness at the end of the "***15 Minutes of Terror***". However, when we look back in 2026, we can see that those 2.1 kilometres weren't a dead end. They stood in for a classroom.

THE *"BAAHUBALI"* ASCENT AND THE DREAM OF THE SOUTH POLE

The adventure started with the GSLV Mk-III's deafening roar, which the Indian audience lovingly called "Baahubali." It carried more than just a three-part spacecraft—the Pragyan rover, the Vikram lander, and an Orbiter—when it blasted out from the Satish Dhawan Space Centre on July 22, 2019. It bore the strategic burden of a country claiming its position in the New Space Age.

India's aim was the Lunar South Pole, in contrast to earlier US, Russian, or Chinese missions. Temperatures in this area, which has old ice and deep shadows, can drop as low as -230 °C. With its sharp craters and boulders, the landscape is a horror. Why travel there? Because the moon's water-ice, the "gold" of the space era, lies hidden at the South Pole and may one day supply fuel and life support for missions headed to Mars. The possible prize was the keys to the solar system, but the technological difficulty was enormous.

Fig. 2: *Pragyan* mounted on the ramp of *Vikram* Lander

ANATOMY OF THE DESCENT: WHAT REALLY HAPPENED?

In order to comprehend the failure, one needs to grasp the physics of a ***"soft landing."*** You can't utilize parachutes in the moon's vacuum. To combat gravity, you have to use ***"retro-braking"***—firing engines downward. There were five 800-Newton liquid-fuel engines on the Vikram lander.

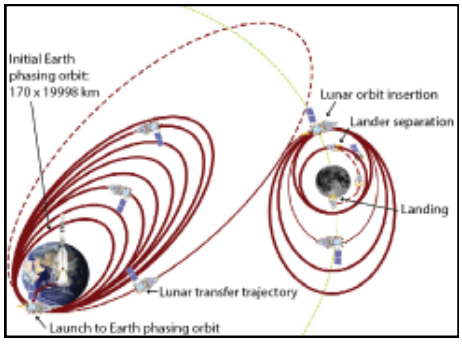

Fig. 3: Chandrayaan-2 roadmap for descent for a successful mission

There were four crucial stages to the descent. The ***"Rough Braking Phase,"*** the first, was a huge success. The engines began to run at a height of 30 km, bringing the lander's horizontal velocity down from 1,680 m/s to almost nothing. The data curves displayed on ISRO Mission Control's screens for ten minutes were exactly in line with the models that were projected. A cautious smile was permitted by the scientists.

This was followed by the ***"Fine Braking Phase."*** In order to position itself for the final touchdown, the lander's onboard computer started doing a number of quick calculations at this point. But there was a "software logic" error. A little more thrust was being produced by the five engines than the algorithms had anticipated. Normally, the computer would compensate by modifying the engines' thrust. However, the software's "correction limit" was surpassed because the deviations were occurring so quickly.

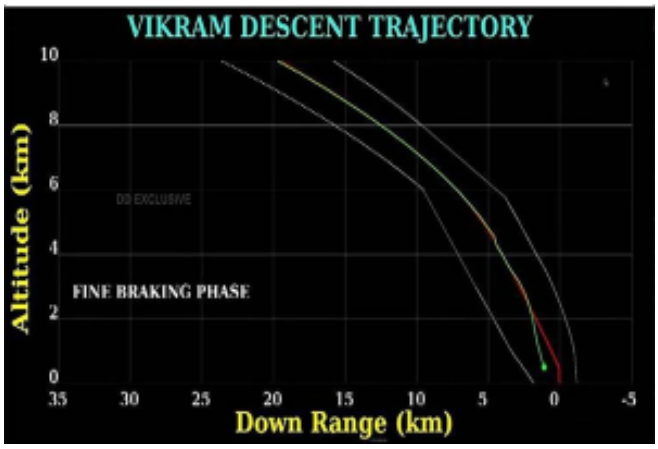

Fig-4: *Vikram* Decent Trajectory, both expected and real

Consider operating a vehicle with a steering wheel that only permits 10° turns, even though the road demands 20° turns. The vehicle, or in this instance, the lander, started to oscillate or "tumble" Its altitude dropped more quickly than its velocity as it attempted to reorient. At 2.1 kilometres above the ground, the communication link broke. It was difficult to make a soft landing because the lander was slanted at an angle and moving too quickly. The mission's mechanical heart was stopped when it probably made a ***"hard landing"*** on the lunar surface at a high speed.

THE HUG HEARD 'ROUND THE WORLD: A CULTURAL SHIFT

A mission failure of this magnitude could have resulted in severe political scrutiny or public mistrust in previous decades. However, 2019 marked the advent of the "connected nation." The

mood within the Mission Operations Complex (MOX) was terrible when word spread of the signal loss. The then-Chairman of ISRO, Dr. K. Sivan, who had led India's space aspirations after rising from a lowly background, was clearly devastated.

Then came the turning point that reshaped Indian scientific culture and leadership. After staying up all night to watch the landing, Prime Minister Narendra Modi did not deliver a speech expressing disappointment. As he was leaving, however, he came upon a sobbing Dr. Sivan in the parking lot, who drew him into a lengthy, quiet embrace.

Not only did this picture go viral, but it also sparked a national dialogue about the "right to fail." Often divisive social media sites like Facebook, Instagram, and Twitter came together to build a cohesive wall of support. For days, the hashtag #IndiaWithISRO was popular. Influencers, actors, cricket players, and regular people started expressing the belief that science is based on the remains of unsuccessful experiments. Because of its public goodwill, ISRO was able to skip the "blame game" and go straight to the "fix-it" stage.

THE LONE WARRIOR: THE ORBITER'S SILENT TRIUMPH

The fact that Chandrayaan-2 was 95% successful was a story that was much overlooked in the tragedy of the disaster. The Orbiter maintained its flawless 100-kilometer lunar orbit when the lander was lost. It was and still is the most advanced piece of equipment India has ever launched into space.

Fig-5: Chandrayaan-2, Vikram Lander and Orbiter in Space

The Orbiter's mission life was increased from one year to seven because of the extremely accurate launch, which also saved a significant quantity of fuel. This "Lone Warrior" has changed the textbooks from 2019 to 2026. It was equipped with the Imaging Infrared Spectrometer (IIRS), which verified that the lunar soil contained hydroxyl (OH) and water

The Orbiter's mission life was increased from one year to seven because of the extremely accurate launch, which also saved a significant quantity of fuel. This "Lone Warrior" has changed the textbooks from 2019 to 2026. It was equipped with the Imaging Infrared Spectrometer (IIRS), which verified that the lunar soil contained hydroxyl (OH) and water (H2O) molecules. With the help of the Orbiter High-Resolution Camera (OHRC), it was able to capture the clearest photographs of the moon ever—clear enough to identify a small pebble in the distance of 100 kilometres.

This Orbiter served as the future's "scout" in addition to being a scientific instrument. The exact landing spot that would ultimately make Chandrayaan-3 a worldwide success was mapped over the course of years. It demonstrated that the brain can overcome a disability to complete a mission in space.

FROM CRASH SITES TO COSMIC LESSONS

The engineering mindset of ISRO underwent a significant change as a result of the post-mortem of the Chandrayaan-2 disaster. "Success-Based Design" was replaced with "Failure-Based Design." They asked not only "How do we land?" but also "What if the engines fail?" for the next trip. What happens if the sensors stop working? What happens if the landing page is too small?

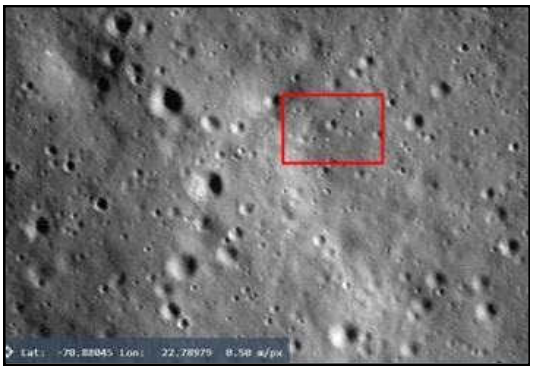

Fig-6: Lunar Surface Imaging from orbital to find *Vikram* Lander

To withstand a more severe impact, they reinforced the legs of the subsequent lander. They expanded the landing area to a huge 4km × 2.4km rectangle from a small 500m × 500m square. To ensure that the vehicle could still provide power even if it landed at an uncomfortable angle, they added more solar panels. In order to detect speed more precisely than the sensors that failed in 2019, they added a Laser Doppler Velocimeter.

Vikram's crash was an investment in data rather than a loss of money. Prior to the collision, every millisecond of telemetry data was valuable. India was eventually able to see the historic "Surya Namaskar" on the moon in 2023 because to the data.

THE LEGACY IN 2026: A NATION UNSTOPPABLE

The ghost of Chandrayaan-2 no longer lingers in the corridors of ISRO as India gets ready for the Gaganyaan mission, which would put humans into orbit, and works with Japan on the LUPEX polar expedition in 2026. Rather, it reminds us to be resilient.

We discovered that the only reason the "15 Minutes of Terror" is frightening is if you're scared of losing. India shown its lack of fear. We discovered that a country's character is determined by how it responds to its difficult times rather than by how well it handles its smooth ones. The cheers of 2023 finally broke the 2.1 kilometres of quiet in 2019, and as India looks to the stars, those cheers continue to reverberate today.

The Moon is now a familiar neighbour rather than a far-off mirror. And we owe the bridge we've constructed to get there to the "failure" of 2019.

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THE BINARY OF LIFE

In the labs of our mind, where the currents sparks,
A wave of logics that rules our heart.
Life isn't a smooth DC, but a wavering line,
A complex signal, a unique design.

Resistance is waiting, in the paths that we choose,
A friction of spirit, and something to lose.
But without that push-back, the heat, and the fire,
How will our voltage ever reach any higher?

We sit in front of the Logic Gates, weighing the "If,"
As we love the steady progress but fear the cliff.
But sometimes,
An "AND" is the bond that we need,
While an "OR" can let our dreams succeed.

May our Potential be high, a stored-up grace,
Ready to fuel our dreams of a far-reaching place.

Don't fear the AC, the ups and the downs,
This is the life we all are bound.
The peaks give us vision…
The troughs? They are just grounds.

Filter the Noise—all your doubts and the fears,
Keep the frequency of the pathway to your dreams clear.

Though we are trained for the "Zeros" and "Ones,"
The spectrum of our life has only begun.

So let our electrons of passion take flight,
Through the copper of our courage, towards the destination's light.

Behind the world in the dark is a world that is still,
Waiting for you, your spark, and will.

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আমার ভোকেশনাল ট্রেনিং অভিজ্ঞতা (WBSEDCL)

আমার ইঞ্জিনিয়ারিং পড়াশোনার অংশ হিসেবে আমি West Bengal State Electricity Distribution Company Limited (WBSEDCL)-এ ১৫ দিনের একটি ভোকেশনাল ট্রেনিং করার সুযোগ পাই। এই ট্রেনিংটি ৩০ জুন ২০২৪ থেকে ১৫ জুলাই ২০২৪ পর্যন্ত অনুষ্ঠিত হয়। এই সময়ে আমি বিদ্যুৎ বিতরণ ব্যবস্থা, সাবস্টেশন পরিচালনা এবং বিভিন্ন বৈদ্যুতিক যন্ত্রপাতির বাস্তব ব্যবহার সম্পর্কে অনেক গুরুত্বপূর্ণ জ্ঞান অর্জন করেছি। এই ট্রেনিং আমাকে বইয়ের তত্ত্ব এবং বাস্তব কাজের মধ্যে সম্পর্ক বুঝতে সাহায্য করেছে।

ট্রেনিংয়ের প্রথম দিনে আমাদের একটি পরিচিতি সভা অনুষ্ঠিত হয়, যেখানে WBSEDCL-এর কাজ, দায়িত্ব এবং বিদ্যুৎ সরবরাহ ব্যবস্থার সম্পর্কে বিস্তারিত আলোচনা করা হয়। আমরা জানতে পারি কীভাবে বিদ্যুৎ উৎপাদন কেন্দ্র থেকে সাবস্টেশনের মাধ্যমে গ্রাহকদের বাড়ি ও প্রতিষ্ঠানে পৌঁছায়। এর ফলে বিদ্যুৎ বিতরণ ব্যবস্থার সম্পূর্ণ প্রক্রিয়া সম্পর্কে একটি পরিষ্কার ধারণা পাই।

ট্রেনিং চলাকালীন আমরা স্টোর বিভাগে পরিদর্শন করি, যেখানে বিভিন্ন বৈদ্যুতিক যন্ত্রপাতি ও উপকরণ সংরক্ষণ এবং ব্যবস্থাপনার পদ্ধতি সম্পর্কে শিখি। সেখানে আমরা Distribution Transformer, Cable, Meter, Insulator ইত্যাদি সরঞ্জাম কাছ থেকে দেখতে পাই। এছাড়া SRV, STN, SRN এবং SIRN-এর মতো গুরুত্বপূর্ণ নথিপত্রের ব্যবহার সম্পর্কেও ধারণা লাভ করি। এর মাধ্যমে বুঝতে পারি যে সঠিকভাবে উপকরণ সংরক্ষণ ও ব্যবস্থাপনা করা বিদ্যুৎ সরবরাহের ধারাবাহিকতা বজায় রাখতে কতটা গুরুত্বপূর্ণ।

ট্রেনিংয়ের সবচেয়ে গুরুত্বপূর্ণ অংশ ছিল বিভিন্ন 33/11 kV সাবস্টেশন পরিদর্শন করা। আমরা Mandalgathi, Bagjola, Biserpara এবং New Town AA-II E সাবস্টেশন পরিদর্শন করি। সেখানে আমরা শিখি কীভাবে উচ্চ ভোল্টেজ 33 kV বিদ্যুৎকে 11 kV-এ নামিয়ে গ্রাহকদের কাছে নিরাপদভাবে সরবরাহ করা হয়। আমরা Power Transformer, Circuit Breaker, Isolator, Lightning Arrester, Busbar এবং Control Panel-এর মতো গুরুত্বপূর্ণ যন্ত্রপাতির কাজ সরাসরি পর্যবেক্ষণ করি। ইঞ্জিনিয়াররা আমাদের প্রতিটি যন্ত্রের কাজ সহজভাবে বুঝিয়ে দেন।

এই ট্রেনিংয়ে নিরাপত্তা বিষয়টিকে বিশেষ গুরুত্ব দেওয়া হয়েছিল। আমাদের Earthing system, Fire protection এবং Personal Protective Equipment (PPE) যেমন হেলমেট, গ্লাভস এবং সেফটি জুতা ব্যবহারের গুরুত্ব সম্পর্কে শেখানো হয়। এর ফলে আমরা বুঝতে পারি যে বৈদ্যুতিক কাজের ক্ষেত্রে নিরাপত্তা নিয়ম মেনে চলা কতটা জরুরি।

আমরা Customer Care Centre (CCC) পরিদর্শন করার সুযোগও পাই। সেখানে আমরা জানতে পারি কীভাবে গ্রাহকদের অভিযোগ গ্রহণ করা হয় এবং দ্রুত সমাধান করা হয়। এছাড়া নতুন সংযোগ দেওয়া, বিল সংক্রান্ত সমস্যা সমাধান এবং বিদ্যুৎ পরিষেবা সম্পর্কিত অন্যান্য কাজ কীভাবে পরিচালিত হয়, সে বিষয়েও ধারণা লাভ করি। এতে আমরা বুঝতে পারি যে বিদ্যুৎ পরিষেবা ব্যবস্থায় গ্রাহক সেবার গুরুত্ব অনেক বেশি।

সবশেষে, এই ১৫ দিনের ট্রেনিং আমার জন্য একটি অত্যন্ত মূল্যবান অভিজ্ঞতা ছিল। এই ট্রেনিংয়ের মাধ্যমে আমি বাস্তব কাজের অভিজ্ঞতা অর্জন করেছি, নতুন প্রযুক্তি সম্পর্কে জেনেছি এবং একজন ভবিষ্যৎ ইঞ্জিনিয়ার হিসেবে আত্মবিশ্বাস বৃদ্ধি পেয়েছে। আমি WBSEDCL এবং আমার কলেজের প্রতি কৃতজ্ঞ, যারা আমাকে এই গুরুত্বপূর্ণ শেখার সুযোগ প্রদান করেছে।

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ELECTRIC VEHICLES (EVS) AND CHARGING SYSTEMS: SUMMARY

Introduction

Electric Vehicles (EVs) are transforming transportation by providing a cleaner and more energy-efficient alternative to internal combustion engine vehicles. Rising fuel costs, environmental concerns, and advancements in battery technology have accelerated EV adoption worldwide. Conventional vehicles contributed to economic growth but also caused pollution and resource depletion, leading to the development of EVs and hybrid technologies.

Architecture of an Electric Vehicle

EV architecture integrates electrical and mechanical systems to convert stored energy into motion. It includes battery, motor, power electronics, and control systems.

Main Functional Blocks

- Energy Storage System (Battery Pack)
- Electric Motor & Drivetrain
- Power Electronics & Motor Controller
- Charging System
- Thermal Management System
- Vehicle Control Unit (VCU)
- Auxiliary System

Key Components of EV

1. Energy Storage System (Battery Pack)

The battery pack stores electrical energy and powers the motor and other systems. It determines the driving range and includes battery cells, BMS, cooling system, and protective casing.

2. Electric Motor & Drivetrain

The electric motor converts electrical energy into motion. The drivetrain transfers power to the wheels. Common motors include BLDC, PMSM, and induction motors.

3. Power Electronics & Motor Controller

This system converts DC to AC, controls motor speed, and ensures efficient operation using inverters, converters, and controllers.

4. Charging System

Charging systems replenish battery energy. Types include Level 1 (slow), Level 2 (medium), and DC fast charging.

5. Thermal Management System

Maintains safe temperature levels using cooling methods like air, liquid, phase change, and immersion cooling.

6. Vehicle Control Unit (VCU)

Acts as the brain of the EV, controlling torque, braking, and coordination of systems.

7. Auxiliary System

Includes lighting, safety systems, steering, braking, and infotainment. Powered through DC-DC conversion.

Future Prospects of Electric Vehicles

Future EV growth is driven by solid-state batteries, fast charging, renewable integration, AI, and smart grids. Government policies and investments are accelerating adoption.

Conclusion

EVs represent a sustainable shift in transportation. Advancements in technology and infrastructure are making them more efficient, affordable, and environmentally friendly.

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SMART FAULT DETECTION IN UPFC-ENABLED TRANSMISSION LINES: ENHANCING SAFETY AND RELIABILITY

Electricity is the backbone of modern life. From homes and hospitals to industries and research laboratories, almost every activity depends on a reliable power supply. Behind this seamless availability lies a vast and complex network of transmission lines that transport electrical energy over long distances. Ensuring the safety and reliability of this network is one of the most important responsibilities of power system engineers.

However, transmission lines are constantly exposed to environmental and operational stresses such as lightning, falling trees, insulation failure, and accidental contact with foreign objects. While many faults generate large currents and are quickly detected by conventional protection systems, some faults remain hidden. Among the most challenging of these are High Impedance Faults (HIFs).

High impedance faults occur when a conductor comes into contact with a high-resistance surface like dry soil, asphalt, or vegetation. Because the resulting fault current is very small, traditional relays may not recognize the abnormal condition. Despite the low current, such faults can be extremely dangerous, leaving energized conductors on the ground and posing serious risks to public safety.

The challenge becomes even greater in modern transmission systems equipped with advanced control devices such as the Unified Power Flow Controller (UPFC). While UPFC improves power flow control, voltage regulation, and system stability, it also alters the electrical behaviour of the transmission line. This makes fault detection more complex and demands smarter, more adaptive protection techniques.

In response to this challenge, this article presents a modern and reliable approach for detecting and classifying high impedance faults in UPFC-compensated transmission lines. The proposed method aims to enhance system safety while ensuring dependable operation in today's evolving power grid.

In this article, we explore a modern solution developed for detecting such faults in advanced transmission systems equipped with a device called the Unified Power Flow Controller (UPFC).

Understanding the Problem: What is a High Impedance Fault?

In a typical power system, faults occur when conductors come into unintended contact — such as line-to-ground or line-to-line faults. Conventional protection relays detect these faults by sensing high fault currents and immediately isolate the faulty section.

However, not all faults produce high current.

A High Impedance Fault occurs when a conductor touches a surface with high resistance — such as dry soil, asphalt roads, tree branches, or concrete structures. In such cases:

- The fault current remains very small.
- Conventional overcurrent relays may fail to detect the fault.
- The energized conductor may remain live.
- It poses serious risks to public safety.

Therefore, detecting HIFs is extremely important for preventing electrical hazards and ensuring system reliability.

The Challenge of Modern Power Systems

Today's transmission networks are far more advanced than traditional systems. To improve efficiency and control power flow, modern grids use FACTS (Flexible AC Transmission Systems) devices.

One such powerful device is the Unified Power Flow Controller (UPFC).

The UPFC can:

- Control voltage,
- Regulate active and reactive power flow,
- Improve stability,
- Enhance transmission capability.

While the UPFC improves performance, it also changes the electrical characteristics of the transmission line. As a result, traditional protection schemes may not function accurately in UPFC-compensated systems.

This creates a new research challenge:

How can we reliably detect high impedance faults in transmission lines that include advanced control devices like UPFC?

The Proposed Solution: A Differential Power-Based Approach

To solve this problem, a new protection method was developed based on a simple but powerful idea — comparing power at both ends of a transmission line.

The Basic Concept

Under normal operating conditions:

- Power entering the line at the sending end
- Power leaving the line at the receiving end

The difference between them is very small.

But when an internal fault occurs within the line:

- Some power is absorbed at the fault location.
- The difference between sending and receiving power increases significantly.

This difference is called Differential Power (DP).

If the DP value crosses a predefined threshold, it indicates an internal fault and if the DP remains small, the fault is either external or there is no fault.

Why This Method is Effective

The beauty of this approach lies in its simplicity and reliability.

It uses:

- Voltage and current measurements at both ends of the transmission line.
- Time synchronization (like GPS-based systems).
- Calculation of apparent power for each phase.
- Comparison of differential power values.

Using this method, we can:

Detect internal faults

Identify faulty phase(s)

Distinguish internal faults from external faults

Classify different types of short-circuit faults

Types of Faults Classified

The proposed method successfully classifies:

- Single Line to Ground faults (AG, BG, CG)
- Line-to-Line faults (AB, BC, AC)
- Double Line to Ground faults (ABG, BCG, ACG)
- Three-phase faults (ABC, ABCG)

This makes the system highly versatile for real-world applications.

Simulation and Testing

To validate the performance of the proposed scheme, a 400 kV double circuit transmission system was modelled using MATLAB/Simulink.

Various fault conditions were simulated by varying:

- Fault resistance (from 0 Ω to 600 Ω)
- Fault location (different points along the line)
- Fault inception angle (0° to 90°)
- Line loading conditions
- Source strength (weak and strong infeed)

Key Findings

1. The method accurately detected high impedance faults up to 600 Ω.
2. It worked reliably regardless of fault location.
3. It remained unaffected by fault inception angle.
4. Heavy line loading did not disturb the classification.
5. Even under weak source conditions, the scheme performed consistently.
6. Faults were detected within one cycle of occurrence.

These results confirm the robustness and practical applicability of the approach.

Why This Research Matters

Power system protection is not just about engineering — it is about safety.

High impedance faults can:

- Leave live conductors energized on the ground.
- Cause electric shock hazards.
- Lead to fires.
- Damage equipment.
- Reduce public confidence in power reliability.

As power systems become smarter and more complex, protection techniques must evolve accordingly.

This research contributes toward:

- Enhancing safety in modern grids.
- Improving reliability of UPFC-compensated systems.
- Supporting smart grid development.
- Aligning with PMU-based synchronized measurement technologies.

Educational Significance for Students

For students of Electrical Engineering, this work highlights:

- The importance of power system protection.
- Practical application of synchronized measurements.
- Role of simulation tools like MATLAB/Simulink.
- Integration of FACTS devices in transmission systems.
- How theoretical concepts translate into real-world engineering solutions.

It demonstrates how research in protection engineering directly contributes to public safety and infrastructure reliability.

Future Scope

This work opens up opportunities for:

- Hardware implementation using PMUs.
- Real-time testing in laboratory setups.
- Integration with smart grid monitoring systems.
- Development of intelligent adaptive protection schemes.
- Field-level validation in practical transmission networks.

Conclusion

Detecting high impedance faults in modern transmission systems is a complex but critical task. The presence of advanced devices like UPFC further increases the challenge.

The proposed differential power-based protection scheme provides:

- Accurate detection of internal faults,
- Reliable classification of fault types,
- Robust performance under varying operating conditions,
- Fast response within one cycle,
- Immunity to fault resistance, location, and loading changes.

This research represents a step forward in making power transmission systems safer, smarter, and more dependable.

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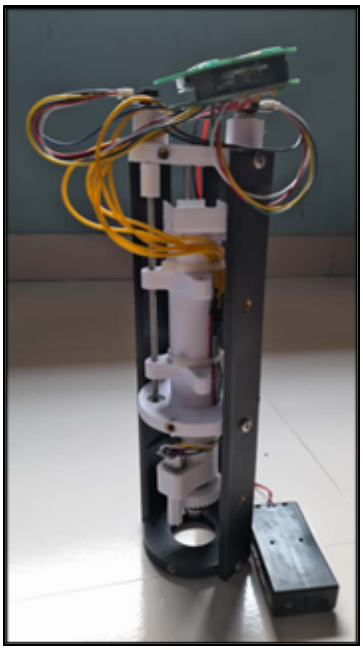
AN IDEA UNDER THE LENS: OUR JOURNEY BUILDING AN IOT MICROSCOPE

Like most final-year projects, ours started with a simple but important question: what should we build? We were clear about one thing—we wanted to work on something related to IoT—something relevant, impactful, and meaningful. Ideas floated around: a smart device? An alarm system? A microscope? A telescope, perhaps? Each option carried its own intrigue, but none yet felt like the one.

We were a team of 3- Prithika Mondal, Hena Mahata, B. Yaminy- working under the guidance of our supervisor Dr. Susmita Dey ma'am.

After discussion with Susmita ma'am, the suggestion of a digital microscope sparked build a something—a quiet excitement mixed with uncertainty. We agreed to explore its feasibility, but clarity was still distant. What exactly would we build? How would it stand apart? At that stage, the idea was more of a question than a solution.



So we turned to research. Hours blurred into days as we explored existing products in the market, studied research papers, and dissected the workings of traditional microscopes, continuously thinking what new we can do so that it stands out. Slowly, patterns began to emerge—not just of what existed, but of what was missing.

As we went deeper, we started identifying common challenges in microscopes: high cost, limited portability, difficulty in achieving precise focus and limited accessibility for field use.

These observations helped us better understand where our project could make a difference. The "problem" transformed into an opportunity. The scope of our work became clearer—not just to microscope, but to rethink it. To make it affordable, portable, and intelligent through IoT integration. So, we started the making of an IoT based auto-focusing portable microscope.

Once the idea was more defined, we moved on to the practical side. Our design kept evolving

as new ideas emerged. We visited local markets to check the cost of components and to study the pricing of existing microscopes. We also spoke to shop owners to get their perspective and see if they had any suggestions.

Not all feedback was encouraging.

One encounter, in particular, left a mark. A shop owner listened to our idea and dismissed it almost instantly. "This won't work," he said bluntly. "You won't be able to build something like this." His words lingered longer than we expected. Doubt crept in. For a moment, the project that once felt exciting now seemed impossibly ambitious. We questioned ourselves—were we aiming too high?

There was a brief phase of hesitation where we questioned our approach.

At that point, our mentor, Susmita ma'am stepped in—not just with guidance, but with belief. She reminded us that trying and giving our best mattered more than the outcome. That support helped us regain confidence and move forward with clarity.

It reminded us why we started in the first place—not to choose the easiest path, but to challenge ourselves.

The project was no longer just an academic requirement. It had become a story of persistence, of pushing past doubt, and of daring to build something meaningful—even when others said we couldn't.

And that was just the beginning.

Looking back, that moment of doubt made us more determined and more thoughtful about our approach.

As we moved into the designing phase, our ideas kept evolving at every step. What we initially planned changed frequently as we explored new possibilities and adapted to practical challenges. Positive feedback during evaluations reassured us that we were on the right track. However, as the final submission approached, we once again felt uncertain about completing everything on time. At that crucial point, guidance from a senior helped us regain direction and move forward effectively.

We were able to achieve our goal.

There were multiple occasions, where we almost gave up on this project. Looking back, the journey was not just about building a device. It was about learning how to approach a problem,

adapt to challenges, and keep moving forward despite uncertainties.

In the end, we felt proud of what we had achieved. The journey showed us that with strong teamwork and the right mentorship, even challenging ideas can be turned into reality. It also became our way of proving that discouragement does not define outcomes—determination and collective effort do.

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বৃষ্টিমুখর গা ছমছমে সেই রাত

আমার নাম নন্দন। পেশায় একজন আমি ইঞ্জিনিয়ার। আমার থাকা হয় চেন্নাইতে। যথারীতি প্রতি বছরের মত আমি শীতের ছুটিতে আমার বাড়ি ফিরছিলাম, আমার বাড়ি পশ্চিমবঙ্গের এক মফস্বল এলাকা নৈহাটিতে। দিনটা ছিল শনিবারের। যথারীতি শুক্রবার ভোরে আমি ট্রেনে উঠে পড়ি। আমার গন্তব্যস্থল ছিল আমার বাড়ি। কিন্তু হয়তো আমি আমার অজান্তেই জানতাম না যে আমাকে এক অদ্ভুত অভিজ্ঞতার সম্মুখীন হতে হবে শনিবারের সেই রাতে।বলে রাখা ভালো আমি একজন এমন মানুষ যে কোনদিনও অশরীরী কোন কিছুতে বিশ্বাস করে না বা করত না কিন্তু সেদিনকার সেই ঘটনা আমার মনের চিন্তার কেন যেন আলোরন ফেলে দিয়েছিল। এবার ভেবেছিলাম বাড়িতে শীতের ছুটিটা বেশ জমিয়ে কাটাবো। তাই দেরি না করে আমি তাড়াতাড়ি শুক্রবার ব্যাগপত্র গুছিয়ে ট্রেনে ওঠার জন্য তৈরি হয়ে গেছিলাম। গন্তব্য স্থলের জন্য যখন রওনা হলাম তখন কেন জানি আমার ডান চোখটা বেশ লাফাচ্ছিল , মাকে বলায় মা তো চিন্তা শুরু করে দিল বলল সাবধানে যেন বাড়িতে ফিরি।যদিও আমি আগেই বলেছি, আমি ওসবে বিশ্বাস করি না তাই মাকে বরঞ্চ রাগের চোটেই বললাম ওসব চিন্তা করো না আমি ঠিক বাড়ি ফিরে আসবো। যথারীতি আমি শুক্রবার বিকেলে ট্রেনে উঠে পড়লাম আমার পৌঁছানোর কথা ছিল শনিবার রাতে। বলে রাখা ভালো আমি সর্বদাই ট্রেন যাত্রা খুবই পছন্দ করি। কারণ ট্রেনে বিভিন্ন রকমের মানুষের সাথে আমার কথাবার্তা বলতে খুবই ভালো লাগে আর বাতাসের ফুরফুরে সেই হাওয়া ট্রেনের ধারের আমার মনকে বড়ই আনন্দ দেয়। শুক্রবারে সেই দিনটা আর শনিবার আমার খুব ভালোভাবেই কাটলো বিভিন্ন মানুষের সাথে কথাবার্তার মধ্য দিয়ে, শনিবার তখন বাজে সন্ধ্যে ছটা শীতটা বেশ ভালই জমেছে। ট্রেনের ধারে বসে আমি তাই ভাবছি। হঠাৎই বর্ষা শুরু হল ট্রেনের জানালা দিয়ে বৃষ্টির ঝাঁপ আমার শরীর প্রায় ভেজাতে থাকলো আমি তখন ট্রেনের জানালা বন্ধ করে দিই। ট্রেনে তখন লোক বেশ কমই ছিল। আমি তখন কি করা যায় কিছু না ভেবে ভাবলাম একটু ঘুমিয়ে নি। তাই যথারীতি আমার ব্যাগের থেকে আমার চাদরটা বের করে আমি গায়ে মুরে নি। আমি ভাবলাম কতক্ষণিবা র ঘুম হবে বড়জোর দু'ঘণ্টা আমার নামার কথা ছিল রাত নটায় ট্রেন থেকে, সেখান দিয়ে বলতে গেলে হাঁটা পথেই আমার বাড়ি। তাই অত কিছু না ভেবে ফোনে রাত আটটার অ্যালার্ম দিয়ে আমি ভাবলাম একটু ঘুমিয়ে নেওয়া যাক। বাইরে তখন খুব জোরে বৃষ্টি পড়ছে, আমি চাদর জড়িয়ে ঘুমিয়ে পড়ি। হঠাৎ এক ব্যক্তি এসে আমাকে ধাক্কা দিয়ে বলে "কি হলো দাদা এখনো ঘুমিয়ে আছেন উঠে পড়ুন এই সিট টা তো আমার"। আমি থতমত খেয়ে উঠে পড়ি আর ঘড়িতে দেখি তখন বাজে রাত দশটা। আমি ওনাকে জিজ্ঞেস করলাম যে আমার স্টেশন নৈহাটি কোথায়? তখন উনি আমাকে উত্তর দিলেন সে তো কখন বেরিয়ে গেছে। আমি তখন খুবই চিন্তায় পড়ে যাই এবং ভাবি যে সত্যিই আমার চোখ লাফানোটা এর কারণ নয় তো। তাও অত কিছু না ভেবে তাড়াতাড়ি আমি পরবর্তী স্টেশনে নেমে পড়ি। আমার ইচ্ছা ছিল যে ট্রেন থেকে নেমে আমি অন্য কোন ট্রেনে করে আমার গন্তব্যস্থলে পৌঁছে যাব। কিন্তু আমি যেই স্টেশনে নামলাম সেই স্টেশনে কোন লোক ছিল না নির্জন স্টেশন। কোন মানুষ নেই সেই স্টেশনে , বোঝাই যাচ্ছিল স্টেশনটি অতো গুরুত্বপূর্ণ

স্টেশন নয়। তখন সবে আমি দেখলাম যে দূরে একটা বাতি জ্বালিয়ে একজন দোকানদার দোকান খুলে বসে আছে বলতে গেলে উনি ওনার দোকান বন্ধই করছিলেন। বৃষ্টি তখন ও পরছে যদিও তার গতি কম। আমি ছুটে যাই সেই দোকানদারের কাছে এবং তাকে জিজ্ঞেস করি" দাদা এখানে পরবর্তী ট্রেন কখন আছে"? সে তখন মুচকি হেসে আমাকে উত্তর দেয় "বাবু বুঝি নতুন এখানে"। আমি একটু রাগের সাথেই তাকে উত্তর দিই "দেখুন হেঁয়ালি করবেন না আমাকে শিগগিরই বলুন পরবর্তী ট্রেন কখন যথেষ্ট বৃষ্টি পড়ছে"। তিনি বলেন "আহা চটছেন কেন আজ আর কোন ট্রেন নেই সব ট্রেন আজকে বাতিল হয়ে গেছে"। আমার তো শুনে চক্ষু ঝড়ক গাছ,আমি তখন মনে মনে ভাবি এই বৃষ্টির রাতে এই নির্জন স্টেশনে আমি এখন কি করব আমি বাড়ি যাব কি করে। আমি যখনই এসব ভাবছিলাম তখনই ওই দোকানদার আমাকে বলেন যে সামনেই একটা হোটেল আছে স্টেশনের একদমই কাছে আপনি ওই হোটেলে গিয়ে আজকে রাত্রি থাকতে পারেন কারণ এই বৃষ্টির রাতে এই স্টেশনে বসে থাকা আপনার জন্য মোটেও ভালো হবে না।আমি ওনার কাছে তখন সেই হোটেলের ঠিকানাটা জানলাম এবং জেনে ভাবলাম যে আজ না হয় এই রাতে হোটেলেই থাকা যাক। এই ভেবে আমি যখন যাচ্ছি তখন সেই দোকানদার বলতে গেলে একটু সতর্কবার্তা আমাকে বললেন যে "বাবু আপনার যাবার রাস্তায় একটা জঙ্গল পড়বে ভুলেও তার ধারে কাছে খুব একটা যাবেন না আজকের রাতটা খুব একটা ভালো না"। আমি ও সব কথায় কান না দিয়ে হোটেলের উদ্দেশ্যে রওনা দি। রাত তখন বাজে মোটামুটি সাড়ে দশটা , বৃষ্টি সবে একটু কমেছে। কালো মেঘ আর শীতল হাওয়ায় রাতটা যেন আরো গভীর মনে হচ্ছিল। রাস্তা দিয়ে আমি তখন একা একা হাঁটছি হঠাৎ দেখলাম একটি বাচ্চা ছেলে আমার দিকে ছুটে আসছে। বাচ্চাটার বয়স ওই পাঁচ থেকে ছয় বছরের মত হবে ছিপছিপে চেহারা খালি গা পরনে শুধু একটি হাফপ্যান্ট। বাচ্চাটি হাতে একটি বল ছিল সে বলটা সে আমার দিকে ছুড়ে মারে। আমি বলটা ধরি এবং সে বাচ্চাটিকে একটু রাগের সাথেই বলি "এই খোকা এত রাতে কি করছিস এখানে? যা বাড়ি যা"। বাচ্চাটি একগাল হাসি নিয়ে আমার দিকে চেয়ে থাকে, তার সে অদ্ভুত হাসি এখনো আমার মনে আছে। বাচ্চাটা আমাকে বলে "আমার সাথে খেলবে"? আমি তখন বলি যে "এই বৃষ্টির মধ্যে এখন কি তোর মজা হচ্ছে আমাকে বিরক্ত করিস না যা বাড়ি যা বলে আমি বলটা ছুড়ে মারি তার দিকে"। বাচ্ছাটা বলটা ধরে দৌড়োতে দৌড়াতে চলে যায়। আমি তখন দেখি বাচ্চাটা দৌড়ে সেই জঙ্গলের দিকে যাচ্ছে। আমার তখন মনে হয় এত রাতে একটা বাচ্চা জঙ্গলের দিকে চলে যাচ্ছে কি যে হবে বাচ্চাটার আমি তাই বাচ্চাটাকে ধরতে যাই। হঠাৎ আমার সেই সতর্ক বাণীর কথা মনে পড়ে যে রাতে জঙ্গলের দিকে যেন না যাই, কিন্তু অত কিছু না ভেবে আমি বাচ্চাটার জন্য জঙ্গলে ঢুকেই পড়ি। কিন্তু অদ্ভুতভাবে বাচ্চাটাকে আর কোথাও দেখতে পাই না আমি। আমি তখন একেবারেই বিধ্বস্ত ক্লান্ত তখন অত কিছু আমি না ভেবে সোজা পিছন ফিরে হোটেলের দিকে রওনা দি। রাত তখন বাজে এগারোটা হোটেলটা ছিল খুবই পুরনো দেখে মনে হবে সেই ব্রিটিশ আমলের। হোটেলের কোন নামও ছিলনা, আমি ভাবলাম আমার কি আমার তো শুধু এই রাত তো থাকা নিয়ে কথা। তাই অত কিছু না ভেবে আমি সোজা হোটেলে ঢুকে পড়ি। যদিও আমি আগে থেকেই জানতাম যে এইসব হোটেলে রিসেপশন না থাকাটাই স্বাভাবিক, তাই আমি হোটেলে ঢুকে ডাক দি " কেউ কি আছেন"? এক মধ্যবয়স্ক লোক বেরিয়ে আসে বলে যে "আমি এই হোটেলের মালিক বলুন কি দরকার আপনার"। আমি তাকে বলি "আপনার কি কোন ঘর ফাঁকা আছে,যদি ফাঁকা থাকে তবে এই রাতের জন্য আমি এখানে থাকতে চাই"। সে মুচকি হেসে বলে এত রাতে এই হোটেলে আপনি যখন এসেছেন আপনি আমার অতিথি আপনার খেয়াল তো আমি অবশ্যই রাখবো বলে সে আমাকে একটি ঘরের চাবি দিয়ে দেয়। তারপর সে আমাকে খাবারের বন্দোবস্ত করে দেয়। আমি রাতের খাবার সম্পূর্ণ করে সোজা ঘরে ঘুমাতে যাই। ঘরে ঘুমাতে যাওয়ার আগে ওই হোটেলের মালিক আমাকে বলেন "বাবু রাতে দরজা ভালো করে বন্ধ করে ঘুমাবেন আর ভুল করেও কোন আওয়াজ পেলে দয়া করে খুলবেন না কারণ গ্রামের রাত তো আর শীতের রাত তাই অনেক রকমের শব্দ আসতে পারে"। আমি ছিলাম খুবই ক্লান্ত তাই কোন উত্তর না দিয়ে কোন কিছু না ভেবে আমি সোজা ঘুমাতে চলে যাই। বাড়িতে মাকে একটা ফোন দি পুরো ঘটনাটা বলি এবং বলি যে কাল ভোরেই আমি বাড়ি চলে আসব। আমার একটা স্বভাব আছে পুরো দিনের ঘটনা রোজ ডায়েরিতে লিপিবদ্ধ করা তাই সেই রাতেও আমি তাই করছিলাম কিন্তু আমি জানতাম না যে রাতটা হয়তো আমার সেদিন তখনও শেষ হয়নি। রাত তখন বাজে বারোটা আমি আমার লেখা সেরে আর কিছু কাজ করে সোজা ঘুমাতে যাই। ক্লান্ত ছিলাম তাই ঘুমিয়ে পরি। হঠাৎ এক আওয়াজ আমার কানে আসে মনে হয় দূর থেকে কোন নুপুরের আওয়াজ গোটা করিডোরে যাওয়া আশা করছে। হঠাৎ আমার ঘুমটা ভেঙে যায় চোখ

খুলে দেখি রাত তখন একটা , নুপুরের আওয়াজটা বাইরে বেশ জোরেই বাজছিল। আওয়াজটা আমার দরজার সামনে খুবই তীব্র হচ্ছিল। আমার তখন আমার হোটেলের মালিকের কথা মনে পড়ে যে রাতে অনেক রকমের আওয়াজ আসতে পারে আমি ভাবলাম এই শীতের রাতে নুপুর পড়ে কে হাঁটবে এখানে? অজানা হোটেল ছিল তাই আমার মনে ভয় লাগলো যে কোন চোর ডাকাত আসেনি তো। বলতে গেলে জীবনে আমি প্রথম ভয় পেলাম আমার রক্ত হিম হয়ে এসছিল চোখ ভয় লাল হয়ে গেছিল। হঠাৎ সেই নুপুরের আওয়াজটা একদমই আমার দরজার সামনে এসে থমকে যায়, তারপর দরজায় সজোরে ধাক্কার আওয়াজ আমি শুনি। জোরে জোরে এক মহিলার বাইরে চিৎকার আমি শুনি, আমাকে বলে যে "বাবু দরজাটা খুলুন আপনি কি আমার ছেলেকে কোথাও দেখেছেন"? আমি ভাবি যাই হয়ে যাক দরজা আমি খুলবো না, কিন্তু সেই আওয়াজ আরো জোরে আমার কানে আসতে থাকে, দরজার ধাক্কা আরো তীব্র হয় এবং একই কথা বারবার আমার কানে আসে" বাবু দয়া করে দরজাটা খুলুন আমি খুবই বিপদে পড়েছি"। আমি অগত্যা কিছু না ভেবে তাড়াতাড়ি বিছানা থেকে উঠে দরজা টা খুলেই দেখি একজন মহিলা পরনে লাল শাড়ি আমার দিকে তাকিয়ে আছে এবং আমাকে বলছে যে "আপনি আমার ছেলে কে কোথাও দেখেছেন ওই স্টেশনের দিকে বল নিয়ে খেলা করছিল"।আমার তখন ওই বাচ্চাটার কথা মনে পড়ে এবং আমি তাকে বলি "হ্যাঁ আমি দেখেছি একটা ৫-৬ বছরের ছেলে ওই জঙ্গলের দিকে চলে গেল"। তখন সেই মহিলা আমাকে বলে যে "আপনি দয়া করে আমার সাথে চলবেন এই রাতে আমি কি করে তাকে একা খুঁজবো"। আমার তখন ব্যাপারটা একটু সন্দেহের লাগলো আমি ভাবি যে এখানকারই গ্রামের মহিলা সে কি করে একজন নতুন মানুষকে তার সাহায্যের জন্য চায়। আমি তাকে উত্তর দিই" না আমি যেতে পারব না"।তখন সে মহিলা আমার দিকে তাকিয়ে তীব্র স্বরে চিৎকার করে এবং বলে যে "আপনার জন্যই আমার ছেলে হারিয়ে গেছে এবং আপনাকে আমার সাথে যেতেই হবে"। তার চিৎকার এবং আওয়াজ কোন মানুষের আওয়াজের মতো শোনা যাচ্ছিল না এক অদ্ভুত আওয়াজ ছিল তার। হঠাৎ তখনই সেই হোটেলের মালিক আমার রুমের সামনে আসে এবং আমার দিকে অদ্ভুত ভাবে তাকিয়ে বলে "বলেছিলাম বাবু, দরজা খুলবেন না"। তারপর সেই মহিলা অদ্ভুতভাবে আমার দিকে তাকিয়ে হাসতে থাকে, আমি তখন খুবই ভয় পেয়ে যাই। আমার মনে হয় যে আমি সত্যিই কোনো বিপদে পড়ে গেছি এরা মনে হয় না কোন ভাল মানুষ। আমি তখন আমার জিনিসপত্রের কথা কিছু না ভেবে সোজা আমি দৌড় লাগাই। আমি হোটেলের সিঁড়ি দিয়ে দৌড়ে নামছিলাম, সিঁড়িটা ছিল খুবই ভাঙ্গা পুরনো দিনের আমি যখন নামছিলাম তখন আমার মনে হচ্ছিল যে ওই দুজন আমার পিছনে তাড়া করেছে। আমি পিছন দিক থেকে ওই হোটেল মালিকের আওয়াজ শুনতে পাই। আমার মনে হল সে আমাকে এক অদ্ভুত হাসির সুরে ডাকছে আর বলছে "বাবু দাঁড়ান যাবেন না এই রাতে আপনার বাইরে যাওয়া ঠিক হবে না"। আমি পিছনে একদমই তাকাইনি এবং সোজা হোটেলের দরজা খুলে আমি বাইরে দৌড় লাগাই। আমি জানতাম না যে আমি কোথায় যাচ্ছি শুধু আমি সেই রাতে ছুটছিলাম হঠাৎই ছুটতে ছুটতে আমি কোথাও সজোরে ধাক্কা খাই এবং পড়ে যাই।যখন আমার চোখ খোলে তখন আমি দেখি ভোর হয়ে গেছে এবং আমি স্টেশন মাস্টারের রুমে একটা বেঞ্চে শুয়ে আছি। স্টেশন মাস্টার আমাকে বলেন যে আপনাকে ভোররাতে স্টেশনের ধারে আহত অবস্থায় দেখা গেছিল ওখান দিয়ে স্থানীয়রা আপনাকে উদ্ধার করেছে। উনি আমাকে প্রশ্ন করেন" এত রাতে আপনি রাস্তায় কি করছিলেন"? আমি তখন ওনাকে সব কথা খুলে বলি এবং আমার সব কথা শুনে ওনার চোখের মনি স্তব্ধ হয়ে যায়।উনি আমাকে বলেন যে "ভালই ঠাট্টা করতে পারেন মশাই আপনি যেই হোটেলের কথা আমাকে বলছেন সেই হোটেল বহু বছর আগে থেকেই বন্ধ হয়ে গেছে এবং সেই হোটেলের কেউ এখানে থাকেই না"।উনি আমাকে বলেন "যাই হোক আপনার ব্যাগপত্র তো এখনো হয়তো এই হোটেলে পড়ে আছে আমি আপনার ব্যাগ পত্র নিয়ে আসার ব্যবস্থা করছি"। বলতে গেলে আমি বুঝতে পারি, সে আমার কোন কথাই বিশ্বাস করছে না এবং হয়তো আমাকে পাগলই ভাবছে। আমি তখন ভাবছি তাহলে সেই রাতে ওই ভদ্রলোক এবং ভদ্রমহিলা তারা কারা ছিলেন তারা কি কোন চোর ডাকাত ছিলেন না তারা অন্য কিছু ছিলেন। আমার মনে হল এখানে কথা না বাড়িয়ে সোজা আমি আমার বাড়ির উদ্দেশ্যে রওনা দিই। আমার ব্যাগ পত্র চলে আসার পর আমি ট্রেন দেখতে পাই এবং ট্রেনে উঠে আমার বাড়ির উদ্দেশ্যে রওনা দি। এবং আমার মনে অদ্ভুত সব চিন্তা চলছে। হঠাৎ যখনই আমার ট্রেন সেই স্টেশনটা অতিক্রম করছিল তখন সেই দোকানের সেই লোকটির চোখে আমার নজর পড়ল এবং আমি দেখলাম যে উনি আমার দিকেই অদ্ভুত চিত্তে তাকিয়ে আছে।

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BUILDING A DIGITAL TWIN FOR TRANSFORMER HEALTH MONITORING

What is a Digital Twin?

A "Digital Twin" is more than just a simulation; it is a dynamic, virtual replica of a physical asset. By retrofitting a standard distribution transformer with a suite of inexpensive sensors (the hardware layer) and connecting it to a cloud-based analytics platform (the software layer), we can create a living digital model of the transformer.

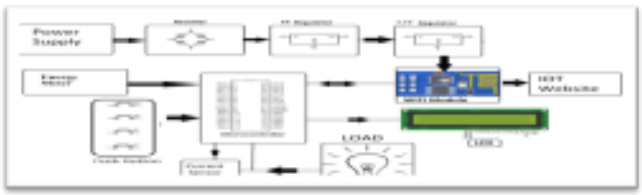
This system does not just report what is happening (e.g., "Current is 50A"); it predicts what will happen (e.g., "At this load trend, internal temperature will exceed safety limits in 2 hours"). This transition from Reactive Maintenance (fixing it when it breaks) to Predictive Maintenance (fixing it before it breaks) is the holy grail of modern power engineering.

In the following sections, we will dismantle the "black box" of the transformer, detailing how a microcontroller-based sensor node and a Python-powered backend can work in harmony to bring the aging grid into the 21st century.

2. The Hardware Architecture (The Physical Layer)

The heart of the system is a robust sensor node designed to retrofit existing transformers.

- The Controller: We utilize the ESP32, a low-cost microcontroller with integrated Wi-Fi and Bluetooth. Its dual-core architecture allows one core to handle sensor data acquisition while the other manages network connectivity, ensuring no data loss during transmission.
- **Sensing Parameters:**
- **Thermal Monitoring**: DS18B20 digital
- temperature sensors are placed on the
- transformer body and oil tank to detect overheating.
- **Electrical Load:** Non-intrusive Split-Core Current Transformers (CTs) measure the load current.
- **Vibration Analysis:** A piezoelectric accelerometer (like the MPU6050) detects abnormal vibrations, which often indicate loose windings or core degradation.



3. The Software Architecture (The Intelligence Layer)

The hardware is useless without the software that gives it meaning. The software ecosystem operates in three stages:

- **Transmission (MQTT Protocol):** Unlike HTTP, which is heavy, we use MQTT (Message Queuing Telemetry Transport). The ESP32 acts as a "Publisher," sending data to a "Broker" (such as a Raspberry Pi or cloud service like AWS IoT Core). This lightweight protocol is ideal for areas with poor cellular coverage, typical of remote substation locations.
- **The Digital Twin (Python Backend):** On the server side, a Python script subscribes to the MQTT topics. It doesn't just store data; it feeds it into a Digital Twin model.
    - Simulation: The software calculates the "expected" temperature based on the current load.
    - Comparison: If the actual sensor temperature is significantly higher than the simulated model, the software flags a "Cooling System Failure" or "Internal Fault" alert.
- **Visualization (The Dashboard):** A real-time dashboard built using Grafana or a custom React.js web app displays the transformer's health status. It provides utility engineers with a "Traffic Light" system: Green (Healthy), Amber (Maintenance Required), and Red (Critical/Shutdown Imminent).

4. Technical Challenges & Solutions

- **EMI Shielding:** Transformers generate massive electromagnetic interference (EMI). The hardware enclosure must be shielded (using aluminum casing or copper tape) to prevent the ESP32 from resetting.
- **Power Supply:** Scavenging power from the transformer's own electromagnetic field using a CT-based energy harvester allows the device to be self-powered, removing the need for battery replacements.

5. Future Scope: Machine Learning Integration

The next step in this technology is implementing TinyML. By training a neural network on the vibration patterns of a healthy transformer, the ESP32 can eventually learn to recognize the specific "hum" of a failing unit locally, without needing to send terabytes of raw data to the cloud.

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“The future is going to be electric.” -- Elon Musk

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