

# Innovative Design of Portable Electrically Insulated Pole Caliper and Safety Tool Carrying System

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**Abstract - The Innovative Design of Portable Electrically Insulated Pole Caliper and Safety Tool Carrying System is developed to improve safety, accuracy, and convenience during electrical line inspection and maintenance work. In electrical distribution systems, linemen frequently measure pole dimensions and carry safety tools while working at heights, which increase the risk of electric shock, tool dropping, and human error.**

This project focuses on designing a portable, lightweight, and electrically insulated pole caliper that allows safe and accurate measurement of electric poles without direct contact. The caliper is made using high-strength insulating materials to ensure protection against electrical hazards. Along with this, a safety tool carrying system is designed to securely hold essential tools, reducing manual handling and improving worker efficiency.

The proposed system enhances operator safety, work efficiency, and reliability while minimizing accidents during live-line or near-live-line operations. This innovative solution is suitable for use in power distribution maintenance, electrical inspection, and field operations, contributing to safer and smarter electrical infrastructure management.

**Keywords:** Portable measuring device, Electrically insulated tools, Pole caliper, Lineman safety, Electrical distribution system, Safety tool carrying system, Live-line maintenance, Electrical hazard prevention, Ergonomic design, Power line inspection.

## I. INTRODUCTION

In the field of electrical power distribution and telecommunication systems, poles serve as the fundamental support structures for overhead lines and cables. These poles, which may be made of wood, concrete, or steel, require regular inspection and maintenance to ensure that they remain strong and safe under varying environmental and electrical conditions. One of the most important parameters in the inspection process is the measurement of the pole's diameter, as it directly relates to its strength, stability, and lifespan.

Traditionally, metallic calipers, tapes, or visual estimation methods are used for this purpose. While these conventional instruments provide acceptable accuracy in ordinary conditions, they are unsafe to use near energized lines because metals conduct electricity, posing severe hazards to maintenance personnel. This problem highlights the urgent need for a measuring device that combines accuracy, portability, and above all, electrical insulation for safety.

The project titled —Innovative Design of a Portable Electrically-Insulated Pole Caliper and Safety Tool-Carrying System was initiated to address this safety gap. The central idea of the project is to design and fabricate a pole-measuring device that can be operated safely in the proximity of live electrical networks without any risk of electric shock. This is achieved by constructing the caliper using non-conductive materials that can withstand high voltage and environmental stresses. Along with the measuring device, the project also introduces a safety tool-carrying system, which ensures the safe storage and transport of the instrument without compromising its insulation quality. Together, these two components form an integrated solution aimed at improving safety, reliability, and ease of use for field workers and technicians.

The background of this project lies in the increasing number of electrical accidents that occur during maintenance work on distribution lines. Many such incidents are caused by the use of conductive tools in areas where even a minor contact with a live conductor can result in severe injury or death. Insulated tools like hot sticks, insulated pliers, and rubber gloves are already standard equipment for linemen, yet there remains a lack of insulated measuring instruments for pole inspection. This project attempts to fill that gap by creating a caliper made from fiberglass-reinforced polymer (FRP) or epoxy-based insulating materials, which offer both high mechanical strength and excellent dielectric properties. These materials not only provide insulation against electric current but are also lightweight, corrosion-resistant, and durable, making them ideal for outdoor field use.

The innovative design of the pole caliper allows for accurate measurement of pole diameters without requiring direct contact between the operator and the structure. The caliper is designed to be attached to an insulated extension pole, similar to those used in live-line maintenance, allowing measurements to be taken from a safe distance. Its jaws or arms are constructed in such a way that they can open and close around the pole smoothly, and the measurement can either be read directly from a scale or displayed digitally through a small electronic sensor. The entire system is lightweight, portable, and easy to operate, making it suitable for regular field inspection work.

An equally important part of the project is the safety tool-carrying system, which provides protection and convenience during the transportation of the caliper and other related tools. This carrying system is made from non-conductive, shock-resistant materials, and is lined with foam or rubber padding to prevent physical damage to the instrument. In many cases, the insulation quality of a tool can degrade due to exposure to moisture, dust, or mechanical abrasion. The carrying system helps prevent such deterioration by keeping the tool clean, dry, and safe during transit or storage. It also improves the organization and accessibility of tools for field engineers, thus increasing overall work efficiency.

The importance of insulation in electrical tools cannot be overstated. According to safety standards such as ASTM F711 and OSHA 1926.957, all tools used in live-line work must be electrically insulated and tested periodically for dielectric strength. The design principles followed in this project are inspired by these standards, ensuring that the prototype meets essential safety requirements. The use of FRP and epoxy composites in the design ensures that the caliper not only resists electrical current but also maintains its strength under different weather conditions such as heat, humidity, or rain. This makes the instrument reliable for year-round outdoor use, a key requirement in electrical maintenance applications.

The overall innovation of this project lies in the successful combination of safety, precision, and ergonomics within a single instrument. The portable electrically-insulated pole caliper eliminates the risk of electric shock during pole measurement and allows field workers to perform inspections quickly and efficiently. Its lightweight construction ensures ease of handling, while its tool-carrying system adds an extra layer of safety and convenience. Moreover, the project demonstrates how practical engineering design and material science can work together to solve real-world safety challenges in the electrical industry. With further development, the concept can be expanded by integrating digital measuring sensors, Bluetooth data logging, or laser-

based non-contact measurement systems for advanced applications.

In conclusion, the project —Innovative Design of a Portable Electrically-Insulated Pole Caliper and Safety Tool-Carrying System represents an important step toward safer and more efficient electrical maintenance practices. It emphasizes the value of engineering innovation in protecting human life while maintaining operational effectiveness. By blending insulation technology, mechanical design, and ergonomic considerations, this project provides a meaningful contribution to the field of electrical safety and measurement systems. The developed design not only addresses current limitations in pole measurement tools but also lays the foundation for future smart and automated inspection devices that can further enhance safety and precision in the power sector.

## II. RELEVANCE

In the field of electrical engineering, worker safety is of paramount importance, especially for those engaged in maintenance, inspection, and repair of transmission and distribution systems. Every year, numerous accidents occur due to the use of conductive tools near live electrical lines. A significant number of these incidents are caused by the lack of electrically-insulated measuring and handling devices, which expose linemen and technicians to high-voltage hazards. This project is directly relevant to solving such safety challenges by providing a portable, non-conductive measuring device that minimizes the risk of electric shock and enhances operational safety during fieldwork.

The portable electrically-insulated pole caliper developed through this project will allow workers to measure pole diameters accurately without physical contact with live components or metallic structures. This is crucial because many existing measuring tools — such as steel tapes and aluminum calipers — are conductive and unsuitable for use in high-voltage environments. The introduction of insulation in the measuring instrument ensures complete operator protection, making it safe to use around power poles, transformers, and distribution lines.

Furthermore, this project aligns with national and international efforts toward improving occupational health and safety (OHS) standards in the electrical sector. It supports compliance with globally recognized safety guidelines such as the Occupational Safety and Health Administration (OSHA) regulations, ASTM standards for live-line tools (ASTM F711), and IEC insulation standards (IEC 60855). By promoting the use of non-conductive materials such as fiberglass-reinforced polymer (FRP) and epoxy composites, the project contributes

to the modernization of field tools in line with the latest technological and safety trends.

In addition to safety, the project is highly relevant from an economic and practical standpoint. Power distribution companies and field contractors often operate in rural or remote areas where access to advanced measuring systems like laser or ultrasonic gauges is limited. The proposed device provides a cost-effective alternative, combining mechanical simplicity with electrical safety. Its lightweight and portable design ensures that even a single operator can carry, assemble, and use it efficiently, thus reducing manpower requirements and increasing productivity.

The inclusion of a safety tool-carrying system adds another dimension of relevance to this project. It protects the caliper from mechanical damage, dust, and moisture, ensuring long-term durability and maintaining the insulation quality of the tool. This feature directly addresses common problems faced by technicians, such as tool contamination and handling difficulty, which can compromise both accuracy and safety during work.

From an educational and research perspective, the project also holds significance for engineering students and researchers, as it bridges multiple domains — mechanical design, materials engineering, ergonomics, and electrical safety. It encourages innovative thinking, practical problem-solving, and the application of interdisciplinary knowledge to create real-world solutions.

In summary, the relevance of this project lies in its potential to enhance safety, improve efficiency, and reduce electrical hazards in field operations. It directly supports the growing need for safer, smarter, and more reliable tools in the power sector. By addressing both technical and human safety aspects, the innovative design of this insulated pole caliper and tool-carrying system stands as a timely and impactful contribution to modern electrical engineering practices.

### **III. LITERATURE REVIEW**

Several conventional measuring devices exist for assessing pole dimensions, such as mechanical calipers, measuring tapes, and ultrasonic or laser-based measurement systems. However, most of these tools are metallic and not suitable for use in high-voltage environments.

Studies and standards from organizations such as the IEEE, ASTM, and OSHA highlight the importance of electrical insulation in tools used for live-line work. The use of fiberglass-reinforced polymer (FRP) and epoxy composites is widely recommended due to their high dielectric strength and mechanical durability. Manufacturers of hot sticks and live-

line tools use similar materials and undergo strict testing to ensure safety.

Research in forestry and field engineering has also introduced portable diameter-measuring instruments using non-contact sensors. While these devices improve accuracy, they are often costly and complex for field maintenance workers. The reviewed literature indicates a gap for a low-cost, insulated, and portable mechanical measuring tool designed specifically for electrical pole inspection — the gap this project seeks to fill.

The development of measuring tools for electrical infrastructure has evolved from simple mechanical instruments to highly specialized insulated devices designed for safety in high-voltage environments. Traditional pole measuring methods relied heavily on metallic calipers and measuring tapes. While these instruments provided accurate results, their conductive nature posed a significant risk when used near live electrical lines. According to studies on electrical maintenance safety, the majority of workplace accidents in power distribution occur due to inadequate insulation of tools or the accidental contact of metallic tools with energized conductors.

In the late 20th century, the use of fiberglass-reinforced polymers (FRP) and epoxy composites became prominent in manufacturing insulated tools like hot sticks, link sticks, and voltage detectors. ASTM F711 and IEC 60855 standards defined the performance criteria and dielectric strength for these materials, marking an important advancement in safety engineering. The Chance-Hubbell catalog (2023) and IEEE safety guidelines recommend FRP materials due to their high mechanical strength, light weight, and resistance to electrical conduction.

Research in the field of forestry and civil engineering has also introduced calipers for measuring tree and pole diameters. For instance, digital forestry calipers use ultrasonic or laser sensors for precise measurement, but these systems are costly and not practical for field electricians. Some portable measuring tools integrate microcontrollers for digital readouts, yet they often lack proper electrical insulation. This gap highlights the need for an affordable, electrically-safe, and mechanically reliable measuring device for electrical maintenance work.

Moreover, the literature suggests a growing demand for ergonomically designed, portable systems that ensure worker comfort during long hours of inspection. Combining this need with electrical safety requirements inspired the present project — an innovative, insulated pole caliper with a dedicated tool-carrying system, offering both protection and convenience.

#### IV. THE PROPOSED WORK

The proposed work involves the design, fabrication, and testing of a portable pole caliper made entirely from non-conductive materials, integrated with a safety carrying system. The device will feature adjustable insulated jaws for diameter measurement and may include a simple digital or analog scale for reading.

The carrying system will be made from non-conductive, shockproof material with foam padding to prevent contamination or mechanical damage. The complete unit will be lightweight, weather-resistant, and easy to handle during pole inspection.

The main objective of this project is to design and fabricate a portable, electrically-insulated pole caliper capable of accurately measuring pole diameters while ensuring complete operator safety. The project also focuses on developing a safety tool-carrying system that protects the caliper from damage and contamination.

The proposed design will use fiberglass-reinforced polymer (FRP) and epoxy resin as primary materials due to their superior dielectric strength and corrosion resistance. The caliper will feature extendable arms or jaws, which can adjust to fit various pole sizes, and a non-conductive measuring scale for precision. To enhance field usability, the entire setup will be lightweight.

A significant aspect of the project is its emphasis on ergonomics and maintenance safety. The design will allow a worker to measure pole diameters from a safe distance, minimizing physical strain and electrical hazards. Additionally, the carrying system will be made from tough polymer materials, lined with soft foam to prevent scratches or moisture accumulation that could compromise insulation.

The project will progress through several stages: conceptual design, CAD modeling, material selection, prototype fabrication, and insulation testing. It aims to demonstrate that a low-cost, insulated measuring device can perform effectively under field conditions without requiring advanced electronics or costly sensors. The final prototype will be analyzed for parameters such as accuracy, insulation resistance, portability, and ease of handling.

#### V. METHODOLOGY

##### 1. Design Stage:

Conceptual design using CAD software (AutoCAD/SolidWorks). Material selection (FRP, epoxy, or polycarbonate).

##### 2. Fabrication Stage:

Manufacturing of insulated jaws and pivot mechanism. Integration of measuring scale or electronic sensor.

Development of carrying case with compartments.

##### 3. Testing Stage:

Mechanical strength and durability testing. Measurement accuracy verification using sample poles.

Insulation resistance testing using a megger or high-voltage test kit.

##### 4. Documentation:

Preparation of testing data, analysis, and final report.

#### VI. FACILITIES REQUIRED

1. Workshop and basic fabrication tools.
2. Electrical testing instruments (megger, multimeter).
3. 3D printer or CNC for component shaping.
4. FRP sheets, epoxy resin, and polymer materials.
5. CAD and simulation software (AutoCAD/SolidWorks).
6. Laboratory setup for insulation and accuracy testing.

#### VII. APPROX. EXPENDITURE

Table no 1

Sr. No.	Components	Price
1	FRP / Epoxy materials	2,500
2	Mechanical hardware & fasteners	1,000
3	Measuring scale / sensor	1,200
4	Microcontroller & display	1,000
5	Tool-carrying case materials	1,000
6	Fabrication and testing expenses	1,500
7	Total Estimated Cost	8,200

#### VIII. TIME SCHEDULE

Table no 2

Month	Work Schedule
Aug 25 – Sept 10, 2025	Finding problem in searching place (hospital, agriculture, petrol pump, MSEB etc.).
Sept 11 – Sept 25, 2025	Discussion on effective problems and identification of most real problem

Sept 26 – Oct 10, 2025	Final selection of problem.
Oct 11 – Oct 25, 2025	Collect references (books, journals, research papers, online sources).
Oct 26 – Nov 10, 2025	Fixing suitable project title.
Nov 11 – Dec 10, 2025	Literature review (study of past work, existing solutions, gap)
Dec 11 – Dec 31, 2025	Discussion on costing of project and estimation of budget (~25k).
Jan 1 – Jan 20, 2026	Preparation of block diagram (input–process–output).
Jan 21 – Feb 20, 2026	Methodology and flowchart preparation.
Feb 21 – Mar 15, 2026	Draft report preparation (Intro, Problem statement, Literature, Costing, Block diagram, Methodology)
Mar 16 – Apr 10, 2026	Correction, editing, and final report writing
Apr 11 – Apr 26, 2026	Final submission, viva and presentation.

### IX. FUTURE SCOPE

The present design can be further enhanced by integrating digital sensors, Bluetooth modules, or laser-based non-contact measurement systems for advanced accuracy. The data from the caliper can be transmitted wirelessly to mobile or cloud platforms for automatic record-keeping. The carrying system can also be developed into a modular safety toolkit for multiple insulated tools. With further refinement, the design can be commercialized for use in power utilities, telecom maintenance, and inspection agencies, contributing to safer and smarter field operations.

The developed portable electrically-insulated pole caliper and safety tool-carrying system can be further enhanced with advanced technologies and industrial-grade features. One of the most promising directions is the integration of digital measurement sensors such as ultrasonic or laser distance modules. These sensors could automatically measure pole diameters and transmit data to a microcontroller-based display for instant readings.

The device can also be upgraded with wireless data transfer capabilities using Bluetooth or Wi-Fi modules, allowing field engineers to log and monitor measurements via mobile applications or cloud platforms. This would be beneficial for smart grid maintenance systems and IoT-based field monitoring, where data collection and safety compliance are crucial

Another future improvement lies in developing modular attachments for the caliper, enabling it to measure not only poles but also other cylindrical structures such as pipes, insulators, and conductors. The carrying system can be redesigned into a multi-tool safety kit that includes insulated screwdrivers, pliers, gloves, and a compact digital tester, making it an all-in-one safety solution for electrical workers.

With further research and refinement, the design can be commercialized and mass-produced for power utilities, electrical contractors, and government agencies. Its affordability and reliability make it a strong candidate for inclusion in PM Surya Ghar Yojana or rural electrification maintenance programs, where safety and cost-effectiveness are equally vital. The proposed innovation thus holds immense potential for improving field safety standards, reducing electrical hazards, and promoting modernization in power distribution systems.

### X. CONCLUSION

This project provides a practical and innovative solution to one of the most common safety challenges in the electrical field — the risk of electrocution from conductive measuring tools. The portable electrically-insulated pole caliper, combined with a dedicated safety carrying system, ensures measurement accuracy, durability, and maximum operator protection. The design emphasizes the use of affordable materials and ergonomic construction, making it suitable for industrial as well as educational applications. The successful implementation of this project will promote safer working environments for linemen and engineers while contributing to the advancement of electrical safety engineering.

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