

Design and Development of low-cost compact Electrical Field Detecting Safety Helmet for safety of line workers

Sachin Pathania¹, Poonam Kumari²

University centre of instrumentation and Microelectronics, Panjab university Chandigarh, India

Abstract—Electrical hazards are one of the major threats faced by line workers in the power sector. To mitigate the risk of electrocution, a safety helmet embedded with an electric field detection system has been developed. This system utilizes a simple and cost-effective circuit based on three BC547 NPN transistors to detect the presence of AC electric fields. Once a field is detected, the helmet activates an audible or visual alert to warn the user. This research demonstrates the viability of analog field detection for practical safety applications and proposes a novel, wearable implementation.

Index Terms—Electric field detection, BC547 transistor, safety helmet, line worker protection, non-contact voltage sensing

1. INTRODUCTION

Line workers routinely handle live wires, high-voltage installations, and distribution systems. While protective gear exists, it typically lacks real-time electric field awareness. This study introduces a wearable solution in the form of a safety helmet equipped with a transistor-based electric field detection system. Unlike traditional voltage detectors, this system does not require direct contact with live conductors, thereby enhancing safety without limiting mobility.[1,3]

2. LITERATURE SURVEY

Past studies have explored various electric field detection mechanisms, such as:

- Capacitive sensors: These can detect electric fields but require advanced signal processing.
- Hall-effect sensors: Primarily detect magnetic fields and are unsuitable for open-air AC detection.
- Transistor-based analog circuits:[1] DIY and academic research (e.g., Electrothinks, Lindevs)

validate the use of NPN transistors (like BC547) to amplify weak ambient AC fields for triggering alert systems.

The novelty of this work lies in the integration of this analog detection system into a wearable form factor—specifically a safety helmet—whereas previous systems are mostly handheld or static.[1,2,3]
2.1 Discussions for the research papers:

In recent years, several researchers and designers have focused on developing non-contact electric field detection systems for ensuring the safety of workers handling live electrical lines. Most existing studies have primarily explored either handheld sensors or complex microcontroller-based detection circuits for measuring electric fields near live conductors. As Zhang et al. (2020) proposed a non-contact voltage detector using an STM32 microcontroller that enables accurate detection with added wireless communication. Similarly, the MDPI Sensors (2016) paper presented a capacitive non-contact voltage sensor for three-phase transmission lines, emphasizing theoretical modeling and field distribution studies for more precise measurement. The Energies (2023) paper advanced this further by adding near-end electric field inversion using MEMS sensors, achieving a very low measurement error. While these studies demonstrate the feasibility and accuracy of non-contact voltage detection, they typically involve complex circuitry, advanced signal processing, or costly microcontrollers and MEMS components, which can increase the cost and technical complexity of deploying such systems widely in the field — especially in rural areas or among low-income line workers.[6]-[15]

3 MATERIAL AND METHODS

A simple electric field detector circuit was built using easily available components. The design includes a

copper wire antenna, three BC547 transistors for signal amplification, resistors for biasing, and a buzzer or LED for output. The whole circuit is powered by a 9V battery and assembled on a small PCB that fits inside a standard safety helmet. The antenna is positioned around the helmet rim for better detection range, providing a practical and lightweight solution for line worker safety.[3]

3.1 Block diagram

The block diagram of our system is shown below. This block diagram shows how our system detects and alert the worker,

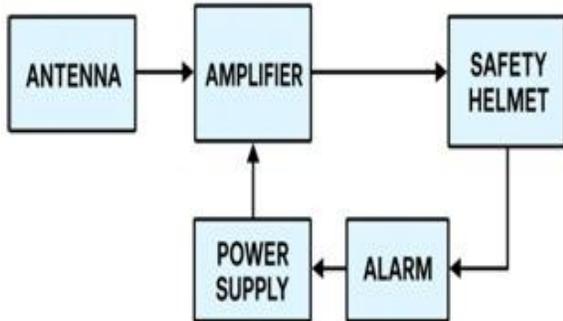


Figure 1: Block diagram

3.2 Components:

- 3x BC547 NPN Transistors
- Resistors: 1kΩ, 10kΩ, 100kΩ
- LED or Buzzer
- Antenna (copper wire)
- 9V Battery
- Standard Safety Helmet

3.2 Circuit Design

The circuit consists of a three-stage amplifier. The antenna picks up ambient electric fields, which are amplified sequentially by each transistor stage. The final stage triggers a buzzer or LED.

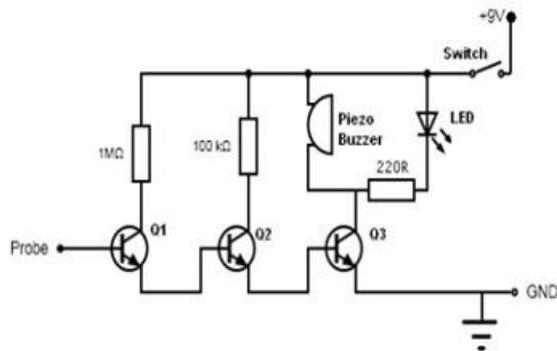


Figure 2: circuit diagram

3.4 Flow chart:[3]

Given flow chart shows the flow of signal and alerting the workers (stop)

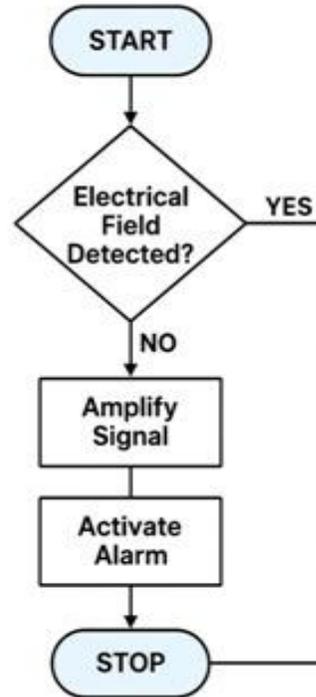


Figure 3: Flow chart

3.5 Assembly:

The circuit is mounted on a small PCB and integrated inside the helmet. The antenna is routed along the rim of the helmet. Power is supplied using a compact 9V battery.

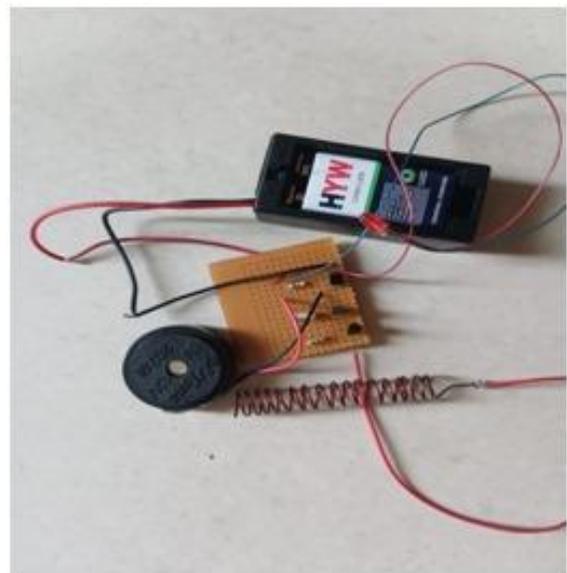


Figure 4: Assembled Circuit

4. RESULTS AND ANALYSIS

- For households connections Sensor detected the electric field at the range 5-6 inches from live wire and 2-3 inches nearer to switch boards



Figure 5: Detecting system

- AS is known transmission lines of different voltage rating require different ground clearances. So this safety helmet can capture electric field from the ground depend upon the height of conductors. This table shows the maximum height from the ground suitable for detection of the field if the line is live.

Table 1: Tested range

Transmission line rating	Range
11-33KV	3-4 meters
132 KV	6-7 meters

5. DISCUSSION

Compared to digital or microcontroller-based systems, this analog design offers simplicity, affordability, and adequate performance for preliminary detection. It is ideal for use in rural or budget-constrained environments where sophisticated tools are unavailable. The total cost for the project is approximately Rs 500/- . The components was buy from market and online sites thus it costs more and that can be reduced if we buy them in bulk for bulk production

6. CONCLUSION

This project successfully demonstrates a low-cost, analog-based electric field detector embedded in a

safety helmet. It significantly enhances line worker safety by offering non-contact, real-time electric field alerts. Unlike microcontroller-based systems, this analog approach avoids calibration issues and reduces cost by 40%.

7. FUTURE WORK

- Upgrade to microcontroller-based detection for better sensitivity control
- Wireless alert systems for supervisors
- Solar-powered operation
- Integration with mobile apps for tracking and diagnostics

REFERENCES

- [1] B. L. Theraja, Basic Electronics, New Delhi: S. Chand, 2015.
- [2] CN104730352A, Electric Field Safety Helmet Patent, 2015.
- [3] A. Smith et al., "Design of Non-Contact Voltage Detectors for High-Voltage Systems," IEEE Transactions on Power Delivery, vol. 34, no. 2, pp. 451–459, Apr. 2019.
- [4] P. Kumar and R. Sharma, "Affordable Safety Devices for Line Workers in India," IET Generation, Transmission & Distribution, vol. 14, no. 11, pp. 2187–2195, 2020.
- [5] IEEE Safety Standards for Line Workers.
- [6] M M. S. Ab Kadir, M. Izadi, S. M. Bashi]"A Smart Helmet for Improving Safety in Electrical Work Environments" International Journal of Electrical and Electronics Engineers (IJEED), 2017
- [7] M. S. Ab Kadir, M. Izadi, S. M. Bashi Development of a Non-Contact Electric Field Strength Detector for High Voltage Electric Installations. IEEE International Power Engineering and Optimization Conference (PEOCO), 2010
- [8] M. X. Li, Y. Wu, X. Zhang Design of a Wearable Voltage Detector for Electrical Workers IEEE Transactions on Industry Applications, 2015
- [9] R. Khalil, M. Shoyama A New Wearable System for Electric Field Sensing in Power Line Maintenance. IEEE Sensors Journal, 2018

- [10] Y. Luo, H. Peng, Non-Contact Voltage Detection Based on Capacitive Coupling, IEEE Transactions on Instrumentation and Measurement, 2012
- [11] P. Arun, S. Anuradha, R. Prasad, Design and Development of Non-Contact Electric Field Sensor for Live Wire, International Journal of Engineering Trends and Technology (IJETT), 2016
- [12] S. H. Won, J. H. Lee, H. Y. Hwang, An Electric Field Probe for Non-Contact Voltage Detection, IEEE Transactions on Power Delivery, 2005
- [13] D. S. Kumar, M. Senthil Kumar, Design and Implementation of a Non-Contact Voltage Detector Using BJTs, International Journal of Electrical Engineering and Technology (IJEET), 2017
- [14] Xuemin Zhang, Hardware Design of Non-contact Voltage Detector Based on STM32 Microcontroller, 2020, IOP Conference Series
- [15] Study and Experiment on Non-Contact Voltage Sensor Suitable for Three-Phase Transmission Line, Sensors Journal, 2016