


# A Novel and Extremely Fast Saturation Less Circuit Breaker Using Non-Mechanical Components

Samira Mohamed Hassan Shaloh  
*British University in Dubai, UAE*


Shakeel Ahmad Sofi  
 <https://orcid.org/0009-0007-8202-8048>  
*Oxford Business College, India*

Amaan Abbas  
*University of Kashmir, India*

Sarwar Khawaja  
*Oxford Business College, UK*

Fayyaz Qureshi  
*Oxford Business College, UK*

Hafsa Hassan  
*University of Kashmir, India*

Azadeh Amoozegar  
 <https://orcid.org/0000-0003-4988-5113>  
*INTI International University, Malaysia*

Shouket Ahmad Tilwani  
*Department of English, College of Science and Humanities,  
Prince Sattam Bin Abdulaziz University, Saudi Arabia*

Huda Majeed  
*Department of English, College of Science and Humanities,  
Prince Sattam Bin Abdulaziz University, Saudi Arabia*

**Received:** August 10th, 2025 | **Accepted:** December 31st, 2025

## ABSTRACT

Modern dependence on electrical equipment increases risks of overloading and short circuits, which can cause severe damage and loss of life. Conventional protection devices, such as fuses and miniature circuit breakers (MCBs), have drawbacks. Fuses require replacement, and MCBs rely on slow mechanical tripping, allowing damaging current surges and suffering from wear over time. The authors propose a solid-state MCB with ultra-fast tripping, enhanced reliability, and a longer lifespan. This MCB uses an air core current transformer, adjustable RC (Resistor Capacitor)-based delays, and analog signal processing, thereby ensuring precise fault detection and minimal response time. Comparative tests with digital controls and noise analysis confirmed their efficiency, making it a superior alternative to traditional devices.

## KEYWORDS

MCB, Solid State Circuit Breaker, Fast Tripping, Analog Signal Processing, Air Core-Transformer

## INTRODUCTION

Circuit protection devices, such as miniature circuit breakers (MCBs), are widely deployed in residential, commercial, and industrial systems to safeguard against overloads and short circuits (Hamid et al., 2022; Jeong et al., 2013). Conventional MCBs, although they are convenient and widely adopted, rely on electromechanical mechanisms that exhibit slow tripping times (50–100 milli seconds), arcing, thermal wear, and core saturation in current transformers (Li & Shengxue, 2019; Ugalde-Loo et al., 2023). These limitations increase risks of conductor heating, equipment damage, and reduced operational lifetime.

DOI: 10.4018/IJCAC.401331

This article published as an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>) which permits unrestricted use, distribution, and production in any medium, provided the author of the original work and original publication source are properly credited.

Recent research has explored solid-state and hybrid circuit breakers that achieve fault interruption within a few milliseconds, offering improved speed and longevity (Abadi et al., (2025) [1] IEEE Power Electronics Society Magazine Editorial Team, 2024–2025; Kheirollahi et al., 2023; Lyu et al., 2022; Rahimpour et al., 2022; Zhang et al., 2023). Hall effect sensors and iron-core current transformers have been used for current detection, but they suffer from offset drift and saturation at high fault currents (Ugalde-Loo et al., 2023; Xiao et al., 2022). Likewise, microcontroller based implementations provide flexibility but introduce computational delays, limiting responsiveness under fault conditions (Singh & Kumar, 2023; Taherzadeh et al., 2023). For example, Abadi et al. (2025) demonstrated an Arduino ACS712–based overcurrent protection system for induction motors, but its reaction speed remains constrained by microcontroller processing and sensor response.

Despite advances, there remains a gap in achieving sub-millisecond fault interruption with simple, scalable, and energy-efficient designs suitable for low-voltage AC systems (Abirami et al., (2016) [16]; Jafari et al., 2024; Kumar & Singh, 2024; Moradian et al., 2025). In this article, we address that gap by presenting a Solid State MCB (SS-MCB) that uses the following components:

- an air core current transformer for linear, saturation-free sensing,
- an analog comparator-based protection circuit with an adjustable Resistor–Capacitor (RC) delay to discriminate inductive inrush from faults, and
- a solid-state relay for arc-free interruption.

The Solid State MCB achieves cutoff times below 10 milli seconds (minimum 300  $\mu$ s) with 60% lower power consumption compared with a digital microcontroller-based prototype while also reducing harmonic distortion through integrated electromagnetic interference (EMI) filtering.

The following are key contributions to this work:

- Development of an analog solid-state breaker achieving sub-millisecond fault interruption.
- Demonstration of saturation-free sensing using an air core transformer.
- Quantified improvements in cutoff speed, power consumption, and harmonic distortion over both digital and conventional MCBs.
- Experimental validation with detailed waveform, Fast Fourier Transform (FFT), and total harmonic distortion (THD) analysis.

The rest of this article is organized as follows. In Section “Switching Process Mechanism” we review conventional MCB mechanisms and related work. In Section “MCB based on Digital Circuit”, we present the microcontroller-based digital breaker prototype. In Section “Solid-State Device–Based MCB Design”, we detail the proposed analog solid-state design. In Section “Results and Discussion”, we discuss the results, including those from the FFT/THD analysis. We conclude the article with Section “Cloud and Internet of Things Integration for Smart Energy Systems” in which we discuss performance comparison, limitations, and future directions.

## CONVENTIONAL SWITCHING PROCESS MECHANISM

The operating principles of MCBs can be broadly classified into three categories: (a) thermo-magnetic, (b) assisted thermal, and (c) magneto-hydraulic (Silva et al., 2025). In thermo-magnetic breakers, the time-delay response is governed by a bimetallic strip, and instantaneous tripping is provided by a separate magnetic mechanism. In the assisted thermal approach, the bimetallic element is additionally influenced by a magnetic force to enhance its response. The magneto-hydraulic mechanism, on the other hand, incorporates a sealed dashpot filled with fluid and a spring, where an

16 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: [www.igi-global.com/article/a-novel-and-extremely-fast-saturation-less-circuit-breaker-using-non-mechanical-components/401331](http://www.igi-global.com/article/a-novel-and-extremely-fast-saturation-less-circuit-breaker-using-non-mechanical-components/401331)

## Related Content

---

### Empirical Comparison of Energy Efficiency Between 3-Tier and High-Speed 3-Tier Network Topologies

Manal Alkoshmanand Saleh Atiewi (2023). *International Journal of Cloud Applications and Computing* (pp. 1-28).

[www.irma-international.org/article/empirical-comparison-of-energy-efficiency-between-3-tier-and-high-speed-3-tier-network-topologies/332766](http://www.irma-international.org/article/empirical-comparison-of-energy-efficiency-between-3-tier-and-high-speed-3-tier-network-topologies/332766)

### Big Data Analytics for Childhood Pneumonia Monitoring

Suresh Kumar Peddoju, Kavitha K.and Sharma S. C. (2017). *Cloud Computing Systems and Applications in Healthcare* (pp. 77-98).

[www.irma-international.org/chapter/big-data-analytics-for-childhood-pneumonia-monitoring/164578](http://www.irma-international.org/chapter/big-data-analytics-for-childhood-pneumonia-monitoring/164578)

### AI-Driven Assistive Technologies: Cloud Infrastructure for Enhanced Accessibility and Inclusion

Surabhi Anand, Sahil Miglaniand Royana Anand (2025). *Establishing AI-Specific Cloud Computing Infrastructure* (pp. 307-318).

[www.irma-international.org/chapter/ai-driven-assistive-technologies/374444](http://www.irma-international.org/chapter/ai-driven-assistive-technologies/374444)

### Cloud Computing Applied for Numerical Study of Thermal Characteristics of SIP

S. K. Maharana, Praveen B. Mali, Ganesh Prabhakar, Sunil Jand Vignesh Kumar (2011). *International Journal of Cloud Applications and Computing* (pp. 12-21).

[www.irma-international.org/article/cloud-computing-applied-numerical-study/58058](http://www.irma-international.org/article/cloud-computing-applied-numerical-study/58058)

### Optimal Resource Usage in Multi-Cloud Computing Environment

Veena Goswamiand Choudhury Nishkanta Sahoo (2013). *International Journal of Cloud Applications and Computing* (pp. 44-57).

[www.irma-international.org/article/optimal-resource-usage-multi-cloud/78518](http://www.irma-international.org/article/optimal-resource-usage-multi-cloud/78518)