Advances in Consumer Research
https://acr-journal.com/
Volume-3 | Issue-2 | Feb 2026

Original Researcher Article

Persistent Electrical Overstress Recorder (PEOR) for Circuit Diagnostics

Dr. R. Poornachandran[1], Mrs. B. Dhivya [2], S. Rohan [3], V. Rishikumar [4], S. Sanjay[5], R. Sivanesh[6]
[1]Assistant Professor, Department of Electronics and Communication Engineering, V.S.B Engineering College Karur – 639111
Email ID : Poornachandran6493@gmail.com
[2]Assistant Professor, Department of Electronics and Communication Engineering,V.S.B Engineering College Karur 639111
Email ID : bdhivyaece@gmail.com
[3]Department of Electronics and communication Engineering, V.S.B Engineering College, Karur - 639111
Email ID : rohanselvask@gmail.com
[4]Department of Electronics and communication Engineering,V.S.B Engineering College, Karur - 639111
Email ID : rishikumarloopzz@gmail.com
[5]Department of Electronics and communication Engineering,V.S.B Engineering College, Karur -639111
Email ID : sanjaysathasivam2005@gmail.com
[6]Department of Electronics and communication Engineering,V.S.B Engineering College, Karur - 639111
Email ID : mravichandranrsivanesh@gmail.com

ABSTRACT

The Persistent Electrical Overstress Recorder (PEOR) for Circuit Diagnostics is proposed as an advanced solution for detecting, recording, and analyzing electrical stress conditions in electronic systems. Traditional protection mechanisms such as fuses and circuit breakers provide only a binary indication of failure after an overload event and do not retain any information about the magnitude, duration, or repetition of electrical stress. This limitation restricts accurate fault diagnosis and prevents effective predictive maintenance. The proposed PEOR system continuously monitors over-voltage and over-current conditions during normal operation and permanently stores the detected stress information using non- volatile resistive random-access memory (RRAM). Due to its non-volatile nature, the recorded stress data is preserved even during power interruptions, ensuring complete stress history retention. Furthermore, the inherent multilevel storage capability of RRAM enables representation of stress severity beyond simple binary states. An Internet of Things (IoT) communication module is integrated to transmit the stored stress data to a remote monitoring platform, enabling real-time visualization, early fault warnings, and condition-based maintenance. By combining persistent stress memory with cloud-enabled diagnostics, the PEOR system enhances reliability, safety, and lifetime estimation of electronic circuits. The proposed architecture is well suited for automotive electronics, industrial power systems, and mission- critical embedded applications where undetected electrical stress can lead to latent failures.

Keywords: Electrical Overstress, RRAM, Non-volatile Memory, IoT, Circuit Diagnostics, Predictive Maintenance.

1. INTRODUCTION:

Modern electronic systems are increasingly exposed to electrical overstress conditions such as over-voltage and over- current due to fluctuations in power supply, load variations, and harsh

operating environments. These stress events may not cause immediate failure but can gradually degrade circuit components, leading to unexpected breakdowns and reduced system reliability. Conventional protection techniques, including fuses and circuit breakers, provide only a binary indication after damage has occurred and do not retain any information about past stress events.

To address this limitation, the Persistent Electrical Over-stress Recorder (PEOR) is proposed. The system detects electrical stress conditions and permanently records them using non-volatile resistive random-access memory (RRAM), ensuring that stress history is preserved even after power loss. An integrated IoT module enables remote access to the recorded data, supporting real-time monitoring and predictive maintenance.

Key contributions of the proposed system include:

Continuous detection of over-voltage and over-current events

Permanent storage of stress history using non-volatile RRAM

Retention of stress data during power interruptions

Remote monitoring and diagnostics through IoT connectivity

The PEOR system enhances circuit diagnostics, reliability, and maintenance efficiency in modern electronic applications.

2. RELATED WORK

Electrical overstress protection has been widely studied in electronic systems, with conventional solutions such as fuses,

transient voltage suppressors, and electronic circuit breakers commonly used to prevent catastrophic failures. These methods are effective in isolating faulty circuits; however, they pro- vide only a binary indication of failure and do not retain any information regarding the magnitude, duration, or repetition of stress events. As a result, post-event diagnostics and lifetime estimation of electronic components remain challenging.

Recent research has investigated non-volatile memory technologies, particularly resistive random-access memory (RRAM) and memristive devices, for recording system events and monitoring electrical stress. RRAM devices offer ad- vantages such as low power operation, high scalability, fast switching speed, and the ability to store multilevel resistance states, which enables representation of stress severity beyond simple binary data. Several studies have demonstrated the feasibility of using RRAM as an embedded stress or event memory; however, many of these implementations remain limited to offline analysis.

In parallel, IoT-based monitoring frameworks have been proposed for remote fault detection and condition monitoring in industrial and automotive systems. While IoT platforms enable real-time data access and visualization, they typically rely on volatile memory or continuous connectivity, making them vulnerable to data loss during power interruptions.

Key limitations in existing literature include:

Absence of persistent stress history storage

Limited use of multilevel non-volatile memory for stress recording

Weak integration between stress memory and IoT diagnostics

Inability to retain stress data during power interruption or system shutdown

Dependence on binary fault indicators without capturing stress magnitude or duration

Lack of real-time stress monitoring and event-triggered logging

Proposed System

The proposed Persistent Electrical Overstress Recorder (PEOR) is designed to continuously monitor electrical stress conditions and permanently record these events for reliable circuit diagnostics. The system integrates electrical stress sensing, non-volatile RRAM-based memory, and IoT connectivity into a unified architecture that enables both local and remote analysis of circuit health. Unlike conventional protection mechanisms that provide only post-failure indication, the PEOR system captures and preserves stress history throughout the operational lifetime of the electronic system.

In the proposed design, voltage and current sensing circuits are placed at critical nodes of the electronic system to detect abnormal operating conditions such as over-voltage and over- current. When a stress event exceeds predefined thresholds, the sensing unit triggers a logging operation. The detected stress parameters are encoded and stored in non-volatile

resistive random-access memory (RRAM). Due to its non-volatile nature, the stored data is retained even during power interruptions, ensuring complete preservation of stress history. The multilevel resistance states of RRAM allow representation of stress severity rather than a simple binary fault flag. An Internet of Things (IoT) module is incorporated to enable remote access to the recorded stress data. The IoT interface periodically transmits the stored information to a cloud-based monitoring platform, where the data can be visualized, analyzed, and used for early fault warnings.

This enables predictive maintenance and reduces unexpected system failures.

The key functional components of the proposed system include:

Voltage and current sensing unit for real-time stress detection

Threshold-based event triggering and data encoding

Non-volatile RRAM for persistent stress data storage

IoT communication module for remote monitoring

Cloud platform for diagnostics and predictive analysis By combining persistent stress memory with IoT-enabled

diagnostics, the PEOR system enhances reliability, supports

condition-based maintenance, and improves fault analysis in automotive, industrial, and embedded electronic applications.

Start Block

Upon power-up, the system initializes the stress sensing circuitry, RRAM memory interface, and IoT communication module.

Normal Operation

Under nominal operating conditions, the circuit functions within predefined voltage and current limits, and the system remains in monitoring mode without triggering data logging.

Stress Detection Circuit

The stress detection circuit employs voltage and current sensing elements along with comparator-based threshold logic to continuously monitor electrical parameters in real time.

Overload Event

When the sensed parameters exceed the preset thresholds, an electrical overstress condition such as over-voltage or over- current is detected, generating an event trigger signal.

RRAM Memory Storage

The event trigger initiates a write operation in the non-volatile resistive random-access memory (RRAM), where the stress information is encoded and stored as a stable resistance state, ensuring data retention even during power interruption.

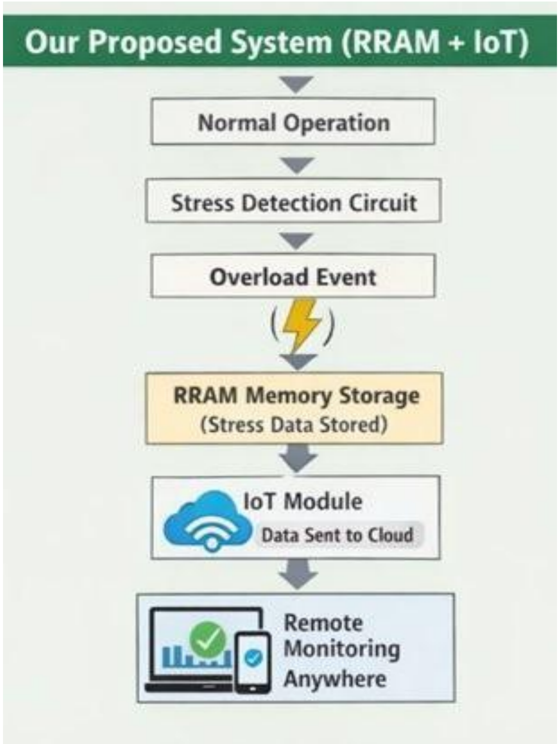

Fig. 1. Our Proposed System (RRAM + IoT) showing the complete operational flow from normal operation through stress detection to remote monitoring.

IoT Module

The stored stress data is transmitted via the IoT communication module to a remote cloud platform using a wireless protocol.

Remote Monitoring Anywhere

The cloud platform enables remote access, visualization, and analysis of stress history, supporting early fault detection and predictive maintenance.

Objective of Invention

Detection of Electrical Overstress

The invention aims to continuously detect electrical overstress conditions such as over-voltage and over-current in electronic circuits using dedicated sensing and threshold-based detection mechanisms.

Persistent Storage of Stress Data

Another objective is to permanently record the detected electrical stress information using non-volatile resistive random- access memory (RRAM), ensuring that the stress history is preserved even during power interruptions.

Beyond Binary Fault Indication

The system is designed to overcome the limitations of traditional protection methods by providing detailed stress information instead of a simple binary blown or not-blown status.

Stress Severity Representation

By utilizing the multilevel resistance states of RRAM, the invention enables accurate representation of stress magnitude and duration, supporting detailed post-event analysis.

Remote Monitoring and Data Accessibility

The invention integrates an Internet of Things (IoT) module to transmit stored stress data to a cloud platform, enabling remote access and monitoring from any location.

Early Fault Warning and Predictive Maintenance

The system aims to support early fault detection and predictive maintenance by analyzing stored stress patterns and trends before permanent failure occurs.

Improved Reliability and System Safety

The proposed invention enhances circuit reliability, safety, and lifetime estimation, particularly in automotive, industrial, and mission-critical electronic systems.

Approach & Technologies Used

System-Level Approach

The proposed Persistent Electrical Overstress Recorder (PEOR) follows a modular and layered design approach that combines real-time electrical stress detection, persistent non- volatile memory storage, and IoT-based remote monitoring. The system is designed to operate continuously alongside the target electronic circuit without interfering with normal operation. When an electrical overstress event occurs, the system captures, records, and communicates the event for diagnostic and maintenance purposes.

Electrical Stress Detection Technique

The system employs voltage and current sensing circuits to monitor electrical parameters in real time. Comparator-based threshold logic is used to identify over-voltage and over- current conditions when measured values exceed predefined safe limits. This threshold-based approach ensures fast response and accurate detection of transient as well as sustained stress events.

RRAM-Based Persistent Memory Technology

Resistive Random-Access Memory (RRAM) is used as the core storage technology for logging stress events. RRAM is selected due to its non-volatile nature, low power consumption, high endurance, and ability to store data as resistance states. The multilevel resistance capability of RRAM enables the system to encode stress severity rather than storing only binary fault information. This ensures retention of complete stress history even during power loss.

Technologies Used

The system incorporates the following technologies:

Voltage and current sensors for real-time electrical monitoring

Comparator and threshold-based detection circuits

Non-volatile RRAM for persistent stress data storage

Microcontroller or embedded control unit for coordination

IoT module for wireless data transmission

Cloud platform for data visualization and diagnostics This combined approach ensures reliable stress recording, enhanced diagnostics, and improved lifetime management of electronic systems.

Hardware Components Description

Power Supply Unit (LM7805)

The power supply unit provides a stable and regulated DC voltage required for proper operation of all system components. The LM7805 voltage regulator converts an unregulated input voltage into a constant +5 V output, protecting sensitive components such as the microcontroller, sensors, and memory devices from voltage fluctuations.

Voltage Sensor (ZMPT101B)

The voltage sensor continuously monitors the supply or load voltage of the circuit. It scales down high voltages to a safe, measurable level and provides an analog output proportional to the sensed voltage. This enables accurate detection of over- voltage conditions.

Current Sensor (ACS712)

The ACS712 is a Hall-effect based current sensor used to measure real-time current flowing through the circuit. It provides electrical isolation and outputs an analog signal proportional to current, allowing reliable detection of over- current events.

Comparator IC (LM358 / LM393)

The comparator compares sensed voltage and current signals with predefined reference thresholds. When the sensed value exceeds the threshold, the comparator generates a trigger signal indicating an electrical overstress condition.

TABLE I

System Components and Their Purpose

Component	**Purpose**
Power Supply Module (LM7805)	Provides regulated +5 V DC supply to the system
Voltage Sensor (ZMPT101B Module)	AC voltage sensing module used for over-voltage detection
Current Sensor (ACS712 – 5A/20A)	Hall-effect based current sensor for over-current monitoring
Microcontroller (ArduinoUno – ATmega328P)	Controls sensing, RRAM access, and IoT communication
RRAM Device (OxRAM / Generic RRAM Cell – Research Grade)	Non-volatile resistive memory for persistent stress storage
Memory Interface (SPI / GPIO-based Interface)	Handles read/write control between MCU and RRAM
IoT Communication Module (ESP8266 / ESP32 Wi-Fi)	Enables wireless data trans-mission to cloud platform
Cloud Platform (ThingSpeak / Firebase)	Used for remote data storage, visualization, and monitoring
Protection Components (TVS Diode, Fuse, Resistors)	Protects sensing and control circuitry from damage

Microcontroller Unit (ESP32 / ATmega328P)

The microcontroller acts as the central control unit of the system. It processes sensor data, manages threshold logic, controls read/write operations to RRAM, and coordinates IoT communication. The ESP32 additionally supports built-in Wi- Fi for IoT functionality.

RRAM (Resistive Random-Access Memory)

RRAM is a non-volatile memory device used to permanently store electrical stress information. It retains data even when power is removed and supports multilevel resistance states, enabling storage of stress severity rather than simple binary data.

Memory Interface Circuit

The memory interface enables controlled communication be- tween the microcontroller and the RRAM device. It manages address selection, write pulses, and read operations required for reliable data storage and retrieval.

IoT Communication Module (ESP8266 / ESP32 Wi-Fi)

The IoT module provides wireless connectivity, allowing stored stress data to be transmitted to a cloud platform. This enables remote monitoring, diagnostics, and predictive maintenance.

Cloud Platform (ThingSpeak / Firebase)

The cloud platform stores incoming stress data and provides visualization tools such as graphs and dashboards. It enables remote access, trend analysis, and early warning notifications.

Protection Components

Protection elements such as fuses, resistors, and TVS diodes safeguard the sensing and control circuitry from excessive voltage or current, ensuring system reliability and safety.

Applications and Advantages

Applications

Automotive Electronics

Records electrical stress in electronic control units (ECUs), enabling early fault detection and improved vehicle reliability.

Industrial Power Systems

Stores overload history in motor drives and inverters, supporting predictive maintenance.

Consumer Electronics

Identifies hidden electrical stress in power adapters and chargers, reducing unexpected failures.

Embedded Systems

Enables persistent health monitoring of electronic circuits deployed in remote environments.

IoT Devices

Retains stress data locally even during power loss and supports remote diagnostics.

Renewable Energy Systems

Logs voltage and current stress in solar inverters for performance optimization and lifetime improvement.

Aerospace Electronics

Improves fault analysis and lifetime estimation in mission- critical electronic systems.

Data Centers and Power Supplies

Detects repeated electrical stress events to prevent catastrophic power failures.

Advantages

The proposed system offers the following advantages:

Permanently records electrical overstress events using non-volatile memory

Retains complete stress history even during power interruption

Enables early fault detection before permanent damage occurs

Supports predictive and condition-based maintenance

Stores stress severity instead of only binary fault indication

Improves reliability and lifetime of electronic circuits

Enables remote monitoring through IoT connectivity

Reduces unexpected system failures and downtime

Compact and energy-efficient system architecture

Suitable for automotive, industrial, and mission-critical applications

Provides accurate post-failure diagnostics using stored stress history

Enables scalable integration with existing electronic systems without major redesign

Supports long-term reliability analysis by tracking re- peated stress events over time

Enhances system safety by enabling timely preventive actions before catastrophic failure

Comparison Between Existing Model and Pro- posed Model

The comparison between the existing stress detection systems and the proposed PEOR system highlights significant improvements. Traditional systems rely on fuses or circuit breakers that provide only a binary blown or not-blown indication after an overload event occurs. Once the protection device activates, no information is retained about the magnitude, duration, or frequency of the stress event. This makes post- failure diagnostics difficult and prevents any form of predictive maintenance.

In contrast, the proposed PEOR system continuously monitors electrical parameters and records every stress event in non- volatile RRAM memory. The system retains complete stress history even during power interruptions, enabling detailed analysis of stress patterns over time. The integration of IoT connectivity allows remote access to stored data, facilitating real-time monitoring and early warning notifications. Further- more, the multilevel storage capability of RRAM enables representation of stress severity, providing much richer diagnostic information compared to simple binary fault flags.

TABLE II

COMPARISON BETWEEN EXISTING AND PROPOSED PEOR MODEL

Parameter	**Existing Model**	**Proposed PEOR Model**
Stress Detection	Detects only severe faults after damage	Detects over-voltage and over-current in real time
Fault Indication	Binary (blown/not blown)	Multilevel stress representation
Stress History Storage	Not available	Permanently stored using non-volatile RRAM
Data Retention	Lost after power failure	Retained even during power interruption
Memory Type	Fuse or volatile memory	Non-volatile RRAM
Remote Monitoring	Not supported	Enabled through IoT connectivity
Severity Information	Not recorded	Records magnitude and occurrence of stress
Fault Diagnostics	Limited post-failure analysis	Accurate diagnostics using stored stress history
System Reliability	Lower due to hid-den stress	Improved reliability and lifetime estimation

3. CONCLUSION

The Persistent Electrical Overstress Recorder (PEOR) system successfully addresses the limitations of conventional protection techniques by detecting over-voltage and over- current conditions and permanently storing electrical stress information using non-volatile RRAM memory. Unlike existing systems that provide only binary fault indication, the proposed approach preserves complete stress history even during power interruptions. The integration of IoT connectivity enables remote monitoring, real-time diagnostics, and early fault warning, supporting predictive and condition- based maintenance.

Overall, the PEOR system improves circuit reliability, safety, and lifetime estimation, making it suitable for auto-motive, industrial, embedded, and mission-critical electronic applications.

Key outcomes of the proposed system include:

Persistent storage of electrical stress history

Reliable detection of over-voltage and over-current events

Data retention during power loss

Remote monitoring and diagnostics through IoT

Enhanced fault analysis and system reliability

Fig. 2. Existing Stress Detection System showing the limitations of conven- tional fuse-based protection with binary output and no data storage capability.

Future Work

Future research directions for the PEOR system include:

Integration of machine learning algorithms for advanced failure prediction

Optimization of RRAM endurance and long-term reliability

Inclusion of additional sensors such as temperature and vibration

Miniaturization of hardware for compact embedded ap-plications

Implementation of low-power design techniques for energy efficiency

Expansion to large-scale industrial and automotive deployments..

REFERENCES

[1] D. Ielmini and S. Ambrogio, "Resistive Switching Random-Access Memory (RRAM): Materials, Mechanisms, and Memory Applications," Chemical Reviews, 2025.

[2] B. Mallala et al., "IoT-Enabled Smart Power Quality Analysis in Three-
Phase Systems," Scientific Reports, 2025.

[3] F. Zahoor et al., "Resistive Random Access Memory: Introduction to Device Mechanism, Materials and Application," PMC, 2023.

[4] IEEE International Electron Devices Meeting (IEDM) 2025, Conference overview on advanced memory technologies and device integration.

[5] "Assessing a Measurement-Oriented Data Management Framework,"
Preprints.org, 2025.

[6] "Machine Learning and IoT for Stress Detection and Monitoring," 2025
(Research)

.