



INNOVATE • CONNECT • INSPIRE

WAVES

DEPARTMENT MAGAZINE

Connecting Ideas, Transforming Futures

VOLUME

08

ISSUE

01

ACADEMIC YEAR
2023-24

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

NBA ACCREDITED | NAAC 'A' GRADE INSTITUTION



INNOVATION

Ideas Today
Impact Tomorrow



RESEARCH & DEVELOPMENT

Advancing Knowledge
Creating Solutions



COMMUNICATION

Connecting Minds
Beyond Boundaries



TECHNOLOGY

Exploring Innovations
Shaping Tomorrow



STUDENT ACTIVITIES

Learn, Lead,
Make an Impact



ACHIEVEMENTS & AWARDS

Recognizing Excellence
Inspiring Success

IGNITING IDEAS • EMPOWERING FUTURES • DRIVING EXCELLENCE

SANTHIRAM ENGINEERING COLLEGE

NANDYAL



ACADEMIC
EXCELLENCE



RESEARCH &
DEVELOPMENT



STUDENT
GROWTH



PLACEMENTS
& TRAINING



INDUSTRY
COLLABORATION



SUSTAINABLE
FUTURE



SANTHIRAM ENGINEERING COLLEGE

Department of Electronics &
Communication Engineering

WAVES | Vol. 08 | Issue 01



ACADEMIC YEAR
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SANTHIRAM ENGINEERING COLLEGE

Department of Electronics &
Communication Engineering



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Autonomous



**NAAC
Accredited**



**NBA Accredited
ECE & CSE**



**AICTE
Approved**



ABOUT THE COLLEGE

Santhiram Engineering College (SREC) is sponsored by M/s Sri Shirdi Sai Educational Academy, Nandyal. SREC was established under the able guidance of Dr. M. Santhiramudu, Chairman, in the year 2007 with the noble motto Education for peace and progress. SREC is approved by AICTE, New Delhi; recognized by UGC under 2(f) and 12(B); permanently affiliated to JNTUA, Ananthapuramu; and certified to ISO 9001:2015. The college is ranked as one of the best engineering colleges of JNTUA, Ananthapuramu.

Santhiram Engineering College (SREC), Nandyal, is an autonomous, NAAC accredited institution offering NBA accredited B.Tech programs in ECE and CSE. Approved by AICTE and recognized by UGC under sections 2(f) and 12(B), SREC delivers outcome-based technical education aligned with industry expectations.

The college offers undergraduate and postgraduate programs such as B.Tech in CSE, CSE-AIML, CSE-Data Science and ECE, along with M.Tech in CSE, CSE-AIML, VLSI System Design (VLSISD), Embedded Systems (ES), MBA and MCA.

With strong placements, research-driven learning, innovation labs and modern infrastructure, SREC prepares students to become industry-ready professionals and future-ready leaders.



SANTHIRAM ENGINEERING COLLEGE

Department of Electronics &
Communication Engineering

WAVES | A Technical Magazine

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ABOUT DEPARTMENT

Anticipating the growing importance of electronics and wireless communication in modern society, the **Department of Electronics and Communication Engineering** was established in 2007 with a vision to impart quality technical education and nurture innovation among young minds.

The department began with an initial intake of **60** students, which was increased to **90** in 2008 and further to **120** in 2009, reflecting the rising demand for skilled electronics and communication engineers.

To meet the expanding needs of the industry and academia, the department introduced a **Master of Technology (M.Tech) program in VLSI System Design** in 2011 with an intake of **18 students**, recognizing the immense potential in the area of Very-Large-Scale Integration (VLSI) design.

The department's B.Tech-ECE program has been accredited by the **National Board of Accreditation (NBA)** for a period of three years, from the academic year **2023-24 to 2025-26**, in recognition of its robust academic framework, quality teaching, and outcome-based education.

The department is also a recognized research center under **Jawaharlal Nehru Technological University Anantapur (JNTUA)**, facilitating research scholars to pursue Ph.D. programs in both full-time and part-time modes, thereby promoting advanced research and innovation.



OUR JOURNEY

- 2007**  Department of ECE established
- 2008**  Intake increased to **90** students
- 2009**  Intake increased to **120** students
- 2011**  M.Tech in VLSI System Design introduced with an intake of **18** students

NBA ACCREDITED



B.Tech-ECE program accredited
by NBA for
2023-24 to 2025-26

RECOGNIZED RESEARCH CENTER



Research center recognized
by **JNTUA** for Ph.D. programs
(Full-time & Part-time)

VISION & MISSION

Vision

To be a center of excellence in Electronics and Communication Engineering education, research and innovation.

Mission

To impart quality education, foster research and innovation, and develop skilled professionals to meet global challenges.

DEPARTMENT FOCUS AREAS



Wireless
Communication



VLSI System
Design



Signal Processing
& Networks



Embedded Systems
& IoT



Antenna &
Microwave Engineering

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“ Empowering Innovation,
Building Tomorrow
Through Electronics &
Communication Engineering ”



SANTHIRAM ENGINEERING COLLEGE

Department of Electronics &
Communication Engineering



VISION & MISSION

INSTITUTION VISION



To become a nucleus for pursuing technical education and pool industrial research and developmental activities with social-conscious and global standards.

INSTITUTION MISSION



To provide Advance Educational Programs and prepare students to achieve success and take leading roles in their chosen fields of specialization.



To establish postgraduate programs in the current and Advanced Technologies.



To establish an R&D Consultancy through developing industry institute interaction, building up exceptional infrastructure.



To propel every individual, realize and act for the technical development of the society.

DEPARTMENT VISION



Emerge as a center for quality education in Electronics & Communication Engineering so as to create competent professionals.

DEPARTMENT MISSION



M1: Offer quality programs in Electronics & Communication Engineering aimed at fulfilling the needs of society and industry.



M2: Impart skills and develop scientific temper to solve complex technological problems of current times.



M3: Nurture ethics, talent and entrepreneurship to inculcate professional development of students.





SANTHIRAM ENGINEERING COLLEGE

Department of Electronics &
Communication Engineering



PROGRAM OUTCOMES (POs)

Under Graduate Program Outcomes

- 01**  **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 02**  **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 03**  **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 04**  **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 05**  **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- 06**  **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 07**  **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- 08**  **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- 09**  **Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- 10**  **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 11**  **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12**  **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.



SANTHIRAM ENGINEERING COLLEGE

Department of Electronics &
Communication Engineering

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UG PEO'S, PG PO'S & PEO'S



UG PEO's - Under Graduate Program Educational Objectives

UG
PEO
01



UG PEO1: Have in-depth knowledge in Electronics and Communication Engineering to innovate, design, and develop modern electronic systems.

UG
PEO
02



UG PEO2: Sustain intellectual curiosity in professional career through life-long learning.

UG
PEO
03



UG PEO3: Have strong work ethics, professional attitude, team spirit, leadership skills, and enterprising skills to serve industry and society.



PG PO's - Post Graduate Program Outcomes

PG
PO
01



PG PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PG
PO
02



PG PO2: An ability to write and present a substantial technical report/document.

PG
PO
03



PG PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.



PEO's - Program Educational Objectives

PEO
01



PEO1: Identify and apply appropriate Electronic Design Automation software and electronic equipment to analyze, synthesize and evaluate to solve real-world problems in the VLSI domain to create innovative products and systems.

PEO
02



PEO2: Pursue research studies in the core or allied areas of the VLSI circuits and systems.

PEO
03



PEO3: Inculcate positive attitude, professional ethics, effective communication, and interpersonal skills to succeed in the profession exhibiting creativity and innovation through research and development both as a team member and leader.



MESSAGES

VOLUME

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2023-24



CHAIRMAN MESSAGE



WAVES is a reflection of our department's spirit, creativity, and commitment to excellence. It showcases the technical insights, innovative ideas, and literary talent of our students and faculty.

I extend my heartfelt appreciation to the entire team for their dedication and hard work in bringing this magazine to life. May WAVES continue to be a platform that inspires curiosity, strengthens knowledge, and encourages every student to express, explore, and excel.

Let the waves of ideas create a sea of innovation!

Dr.M.Santhiramudu
Chairman/Founder



MD'S MESSAGE



I am pleased to see WAVES, the technical magazine of our department, taking shape as a platform for sharing knowledge and innovation. It highlights the remarkable efforts and creativity of our students and the unwavering support of the editorial team. I encourage everyone to contribute, collaborate, and make WAVES a source of inspiration and learning for all readers.

Wishing the team great success in all their future endeavors!

Mr. M. SivaRam
Managing Director

“

*WAVES is not just a magazine,
it is the voice of ideas, the rhythm of innovation,
and the reflection of our vibrant ECE community.*

”



MESSAGES

PRINCIPAL'S MESSAGE



It gives me immense pleasure to present Volume 8, Issue 1 of WAVES. This edition stands as a testament to the unwavering dedication, creativity, and technical excellence displayed by our students and faculty of the Electronics and Communication Engineering Department.

In a rapidly evolving technological landscape, the pursuit of knowledge and innovation is more important than ever. This issue showcases a wide spectrum of advancements, research contributions, and practical solutions that address real-world challenges.

I extend my heartfelt congratulations to the entire team for their commendable efforts in bringing out this issue. I encourage all students to continue their journey of curiosity, learning, and excellence.

Together, let us build a future driven by innovation, integrity, and impact.

Dr. M.V. Subramanyam
Principal

HOD'S MESSAGE



I am delighted to present Volume 8, Issue 1 of WAVES. This issue reflects the dynamic spirit and innovative mindset of our department community. The diverse articles and projects featured in this edition highlight the technical expertise, research orientation, and practical skills of our students and faculty.

I sincerely appreciate the efforts of the editorial team, faculty members, and student contributors for their dedication and hard work.

I encourage all students to keep exploring new ideas, embrace challenges, and contribute to the growth of technology and society.

Let us continue to work together to achieve greater heights and make our department a center of excellence.

Dr. Y. Mallikarjuna Rao
HOD - ECE



ASIC Design of Beamforming Processor for 5G Wireless Networks

INTRODUCTION

The fifth generation (5G) of wireless communication has transformed the way people connect, communicate, and access information. To meet the demand for ultra-high-speed data, low latency and massive connectivity, advanced technologies such as Massive MIMO and Beamforming are essential.

Beamforming directs signals toward specific users instead of broadcasting in all directions, improving signal strength, network capacity, coverage and energy efficiency. ASICs provide an ideal platform for implementing high-speed, real-time beamforming processors with optimized performance and low power consumption.



UNDERSTANDING BEAMFORMING TECHNOLOGY

Beamforming uses multiple antennas to transmit and receive signals in a specific direction.

Traditional Transmission
(Omni-directional)



Beamforming Transmission
(Direction to User)



Benefits of Beamforming

- ✓ Improve signal quality
- ✓ Increase data rates
- ✓ Reduce interference
- ✓ Extend coverage
- ✓ Enhance network reliability

ROLE OF ASICs IN 5G NETWORKS

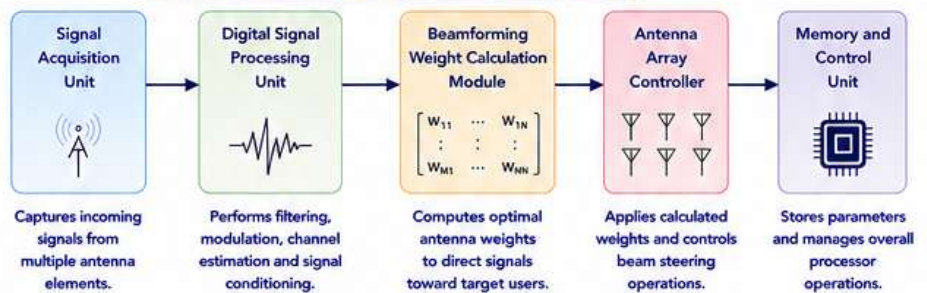
ASICs are custom-designed chips optimized for specific applications. For beamforming in 5G, ASICs offer:

- 1 High-speed parallel processing
- 2 Low latency communication
- 3 Energy-efficient operation
- 4 Reduced hardware complexity
- 5 Compact and scalable architecture



These advantages make ASIC-based beamforming processors highly suitable for modern 5G base stations and devices.

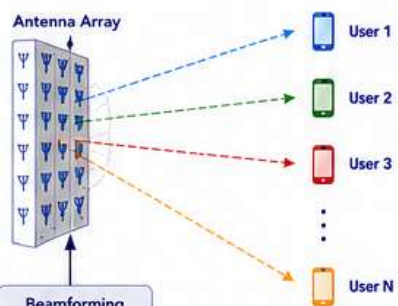
BEAMFORMING PROCESSOR ARCHITECTURE



WORKING PRINCIPLE

The beamforming processor operates through the following stages:

- 1 Receive signals from multiple antennas
- 2 Estimate channel characteristics
- 3 Calculate beamforming weights
- 4 Adjust signal phase and amplitude
- 5 Direct the beam toward the intended user
- 6 Continuously update beam direction based on user mobility



This dynamic process allows the network to maintain strong communication links even in highly mobile environments.

ADVANTAGES OF ASIC-BASED BEAMFORMING

- ✓ High processing speed
- ✓ Low power consumption
- ✓ Improved spectral efficiency
- ✓ Enhanced network capacity
- ✓ Reduced signal interference
- ✓ Lower hardware cost in large-scale deployment
- ✓ Better support for real-time communication



FUTURE SCOPE

Future wireless networks beyond 5G and toward 6G will require more sophisticated beamforming techniques. Emerging technologies such as AI, Machine Learning, Reconfigurable Intelligent Surfaces (RIS), and Terahertz communication will further improve beam management and network performance.



Advanced ASIC designs with AI-based beam selection will enable intelligent, adaptive and energy-efficient communication for future smart environments.

CONCLUSION

ASIC-based beamforming processors provide a powerful solution for achieving high-speed, low-latency and energy-efficient communication in 5G networks. By steering signals precisely capacity, coverage, energy efficiency and reliability, paving the way for smarter cities, intelligent transportation, autonomous systems and the future of global connectivity.



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Energy-Efficient RISC-V Processor Architecture Using Advanced Clock Gating and Power Gating Techniques for Next-Generation Embedded Systems

INTRODUCTION

The rapid evolution of Internet of Things (IoT), Artificial Intelligence (AI), wearable electronics, and smart embedded devices has created a growing demand for energy-efficient computing systems. Modern electronic products are expected to deliver high computational performance while consuming minimal power to extend battery life and reduce operational costs. As the heart of every embedded system, processors play a critical role in achieving this balance between performance and energy efficiency.

Among emerging processor architectures, RISC-V has gained significant popularity due to its open-source nature, modular design, scalability, and flexibility. However, power consumption remains a major concern, especially in portable and battery-operated devices. To overcome this challenge, advanced power optimization techniques such as Clock Gating and Power Gating are increasingly being incorporated into RISC-V processor designs.

RISC-V: THE OPEN-SOURCE REVOLUTION

RISC-V is an open-standard Reduced Instruction Set Computing (RISC) architecture that allows designers to customize processor features according to application requirements. Unlike proprietary architectures, RISC-V provides freedom for innovation while maintaining low hardware complexity and efficient instruction execution.

Its modular structure makes it highly suitable for applications ranging from small embedded controllers to high-performance computing platforms. The architecture also provides an excellent foundation for implementing advanced power-saving mechanisms.

CLOCK GATING FOR DYNAMIC POWER REDUCTION

In digital systems, the clock signal continuously switches between logic states to synchronize processor operations. Even when certain functional units remain idle, the clock continues toggling, resulting in unnecessary dynamic power consumption.

Clock Gating reduces this wastage by selectively disabling the clock signal to inactive modules. When a processor block is not required, its clock is temporarily shut off, preventing unnecessary switching activities.

BENEFITS OF CLOCK GATING

- Reduces dynamic power consumption.
- Minimizes switching losses.
- Improves overall energy efficiency.
- Extends battery life in portable devices.
- Enhances processor reliability.



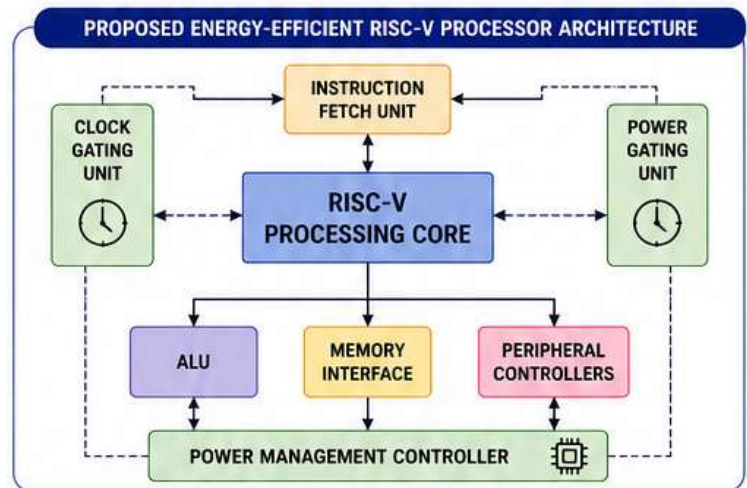
POWER GATING FOR LEAKAGE POWER REDUCTION

As semiconductor technologies continue to scale down, leakage current has become a significant contributor to total power dissipation. This leakage occurs even when circuits are not actively performing computations.

Power Gating addresses this issue by disconnecting the power supply from inactive processor modules using sleep transistors. During idle periods, these blocks enter a low-power sleep mode, significantly reducing leakage power.

ADVANTAGES OF POWER GATING

- Reduces static power consumption.
- Minimizes leakage current.
- Improves thermal performance.
- Increases energy efficiency.
- Extends the operational lifetime of electronic devices.



Key functional units such as the Instruction Fetch Unit, Arithmetic Logic Unit (ALU), Memory Interface, and Peripheral Controllers are continuously monitored for activity.

Whenever a module becomes idle:

- ✓ Clock Gating disables unnecessary clock transitions.
- ✓ Power Gating disconnects power from inactive blocks.
- ✓ Active modules continue operation without performance degradation.

This hybrid power-management approach significantly reduces both dynamic and leakage power consumption while maintaining high computational efficiency.

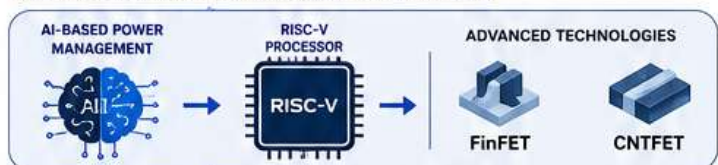
APPLICATIONS

The energy-efficient RISC-V processor can be deployed in a wide range of modern applications, including:



FUTURE SCOPE

Future developments may integrate Artificial Intelligence-based power management techniques capable of predicting workload patterns and dynamically optimizing power consumption in real time. Additionally, implementing RISC-V processors using advanced technologies such as FinFET and CNTFET can further improve performance, reduce leakage power, and enhance overall energy efficiency.



The combination of intelligent power management and next-generation semiconductor technologies will pave the way for highly efficient embedded computing platforms suitable for future smart systems.

CONCLUSION

Energy efficiency has become one of the most important design requirements in modern embedded systems. The integration of Clock Gating and Power Gating techniques within a RISC-V processor architecture provides an effective solution for reducing both dynamic and static power consumption. By achieving high performance with lower energy usage, energy-efficient RISC-V processors are expected to play a crucial role in the development of future IoT devices, AI systems, and intelligent embedded applications.

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AI-Driven Smart Adaptive Image Restoration Framework for Enhanced Vision in Adverse Weather Conditions

WAVES
SREC TECHNICAL MAGAZINE

IMPROVING VISUAL CLARITY AND OBJECT RECOGNITION
THROUGH INTELLIGENT IMAGE ENHANCEMENT TECHNIQUES



Fog



Rain



Snow



Low Light

1. INTRODUCTION

Adverse weather conditions such as fog, rain, snow, and low-light environments severely degrade image quality, affecting visibility and reducing the performance of intelligent vision systems. Smart adaptive image restoration uses advanced AI techniques to enhance visual clarity, improve contrast, and recover lost details for reliable and accurate perception.

2. CHALLENGES IN ADVERSE WEATHER

- Low visibility and blurred scenes
- Scattering and absorption of light
- Loss of contrast and color information
- Noise and artifacts in captured images
- Reduced accuracy in object detection and recognition

5. OUR SOLUTION: SMART ADAPTIVE IMAGE RESTORATION

AI-driven adaptive models intelligently analyze weather conditions and restore images by enhancing details, removing noise, and improving contrast using deep learning.

KEY FEATURES

- Weather Condition Detection
- Adaptive Enhancement
- Detail Recovery
- Real-Time Processing
- Robust and Scalable
- Improved Object Recognition

BEFORE & AFTER RESTORATION RESULTS

FOGGY CONDITION



RESTORED IMAGE



RAINY CONDITION



RESTORED IMAGE



SNOWY CONDITION



RESTORED IMAGE



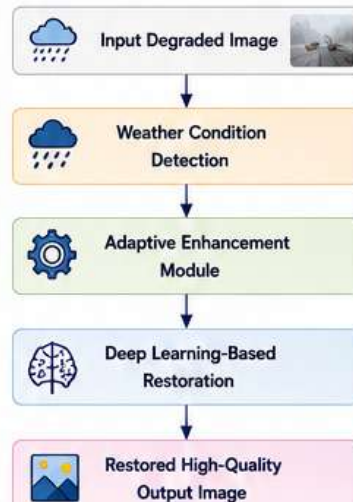
LOW-LIGHT CONDITION



RESTORED IMAGE



3. PROPOSED METHODOLOGY



4. TECHNOLOGIES USED

- Deep Learning (CNN, GAN, U-Net)
- Transformer Networks
- Attention Mechanisms
- Image Enhancement Algorithms
- High-Performance SoC / GPU

6. APPLICATIONS

AUTONOMOUS VEHICLES



Improves visibility and ensures safe navigation in fog, rain, and low-light conditions.

SMART SURVEILLANCE



Enhances surveillance video quality for accurate monitoring and threat detection.

INTELLIGENT TRANSPORTATION



Supports traffic monitoring, incident detection, and smart traffic management.

DISASTER MANAGEMENT



Provides clear visual information during natural disasters for faster response.

DEFENSE & SECURITY



Enhances object detection and situational awareness in harsh environments.

SMART CITIES & IoT

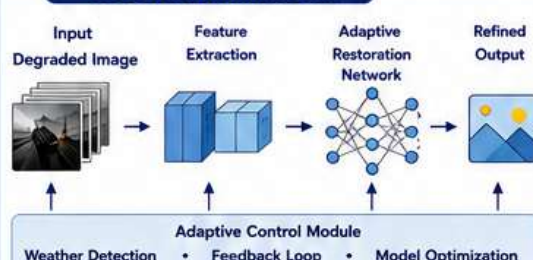


Supports IoT vision systems for environmental monitoring and smart city applications.

7. BENEFITS

- Enhanced image clarity and contrast
- Better object detection and recognition
- Improved accuracy in AI vision systems
- Real-time performance in harsh conditions
- Increased safety and reliability
- Suitable for edge and embedded systems

8. SYSTEM ARCHITECTURE



9. FUTURE SCOPE

- Integration with 6G and Edge AI systems
- Self-learning adaptive enhancement models
- Multi-weather and multi-spectral restoration
- Energy-efficient hardware acceleration
- Federated learning for distributed systems



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Reg No : **20X51A0430**

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“ RESTORING VISIBILITY,
ENHANCING INTELLIGENCE,
EMPOWERING THE FUTURE. ”

Hybrid CNTFET-Based Wireless Communication SoC Architecture for Energy-Efficient Next-Generation IoT Networks

Revolutionizing Future Wireless Connectivity Through Advanced Nanoelectronics and Intelligent System-on-Chip Design

1. INTRODUCTION

The rapid growth of Internet of Things (IoT) applications demands ultra-low power, high-speed and reliable wireless communication systems. Conventional CMOS technology is approaching its physical limits in terms of power dissipation and performance. Carbon Nanotube Field-Effect Transistor (CNTFET) technology overcomes these limitations by offering high mobility, low power, and excellent scalability.

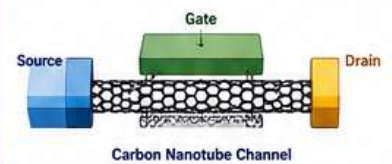
This article presents a **Hybrid CNTFET-Based Wireless Communication System-on-Chip (SoC)** architecture designed for next-generation IoT networks. The proposed SoC integrates RF transceiver, baseband processing, digital controller, and power management using CNTFET and CMOS hybrid technology to achieve optimum performance, energy efficiency, and compact design.



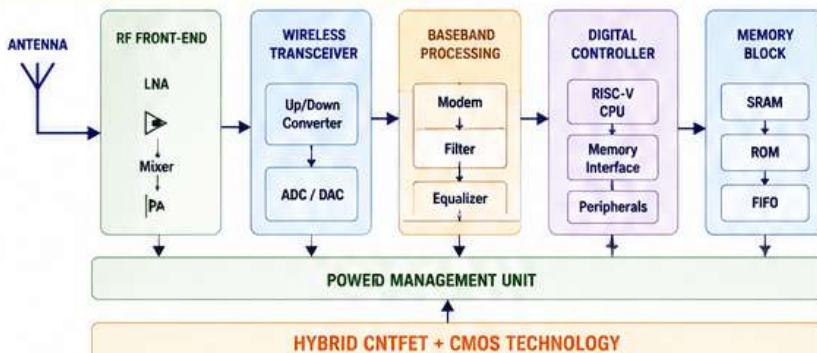
2. WHY CNTFET?

- ✓ Higher carrier mobility than CMOS
- ✓ Lower power consumption
- ✓ Better electrostatic control
- ✓ High current drive capability
- ✓ Excellent scalability for nanoscale
- ✓ Enhanced thermal stability

CNTFET STRUCTURE



3. HYBRID CNTFET-BASED SoC ARCHITECTURE



4. KEY FEATURES

- Ultra-Low Power Operation**
Hybrid CNTFET design reduces dynamic and leakage power.
- High-Speed Communication**
Supports multi-band wireless standards for IoT devices.
- Integrated SoC Solution**
Combines RF, analog, digital and memory on a single chip.
- Energy Efficiency**
Optimized power management for long battery life.
- Security and Reliability**
Built-in hardware security for safe IoT communication.

5. WORKING PRINCIPLE

- 1 The antenna receives/transmits signals from the IoT environment.
- 2 RF front-end conditions the signal.
- 3 Transceiver converts the signal to digital/analog form.
- 4 Baseband processor performs filtering, modulation, and error correction.
- 5 Digital controller manages overall operations and communication.
- 6 Power management unit ensures energy-efficient performance.

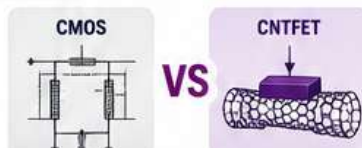


6. APPLICATIONS



7. ADVANTAGES OVER CMOS

- ↑ Higher Speed
- ↑ Lower Power
- ↑ Better Performance
- ↑ More Scalability
- ↑ Longer Battery Life



8. FUTURE SCOPE

- ◆ Integration with AI for intelligent IoT systems.
- ◆ Support for next-generation 5G/6G and beyond networks.
- ◆ Advanced nanoelectronics for sustainable computing.
- ◆ Development of self-powered IoT devices.
- ◆ Enabling smart, secure, and autonomous IoT ecosystems.



9. CONCLUSION

Hybrid CNTFET-Based Wireless Communication SoC is a promising solution for future IoT networks. It offers the perfect combination of high performance, low power, and compact design. This architecture will play a vital role in building intelligent, connected, and energy-efficient IoT ecosystems.





TECHNOLOGY CATCHMENT AREA

REAL-TIME OBJECT DETECTION IN ADVERSE WEATHER USING HYBRID CNN-TRANSFORMER NETWORKS

1. INTRODUCTION

Autonomous vehicles, intelligent transportation systems, surveillance networks, and smart city applications rely heavily on object detection technologies to perceive and understand their surroundings. While modern deep learning models achieve remarkable accuracy under normal conditions, their performance often deteriorates in adverse weather environments such as fog, rain, snow, haze, and low-light conditions. Reduced visibility, motion blur, and atmospheric distortions make object detection significantly more challenging, potentially affecting safety and reliability.

To address these challenges, researchers are exploring Hybrid CNN-Transformer Networks that combine the strengths of Convolutional Neural Networks (CNNs) and Transformer architectures. This innovative approach enables robust and accurate real-time object detection even in difficult environmental conditions.

2. THE CHALLENGE OF ADVERSE WEATHER

Weather conditions directly influence image quality and visibility. In foggy environments, objects appear blurred and lose contrast. Rain introduces streaks and reflections, while snow can partially obscure important visual information. Low-light conditions further reduce the ability of traditional computer vision systems to distinguish objects accurately.

These challenges often result in:

- ⊗ Missed object detections
- ⊗ False alarms
- ⊗ Reduced detection accuracy
- ⊗ Increased processing complexity
- ⊗ Safety risks in autonomous systems

Therefore, developing weather-resilient object detection systems has become a critical research area in Artificial Intelligence and Computer Vision.

3. UNDERSTANDING CNN-BASED DETECTION

Convolutional Neural Networks (CNNs) have long been the backbone of object detection systems. Popular models such as YOLO, Faster R-CNN, and SSD utilize convolution operations to extract local image features such as edges, textures, and shapes.

ADVANTAGES OF CNNs

- ✓ Fast computation speed
- ✓ Strong local feature extraction
- ✓ Efficient real-time processing
- ✓ Suitable for embedded systems



However, CNNs primarily focus on local information and often struggle to capture long-range contextual relationships, especially in degraded visual environments.

4. THE RISE OF TRANSFORMERS IN COMPUTER VISION

Transformers were initially developed for Natural Language Processing but have recently revolutionized computer vision through architectures such as Vision Transformers (ViTs) and Swin Transformers.

Unlike CNNs, Transformers employ self-attention mechanisms that enable the model to analyze relationships among all image regions simultaneously. This allows better understanding of global context, even when parts of the image are degraded by weather effects.

BENEFITS OF TRANSFORMERS

- Capture long-range dependencies
- Better contextual understanding
- Enhanced robustness to environmental variations
- Improved feature representation



Despite their advantages, pure Transformer models often require high computational resources, making real-time deployment challenging.

8. CONCLUSION

Real-time object detection in adverse weather remains one of the most important challenges in modern computer vision. Hybrid CNN-Transformer Networks provide an effective solution by combining the fast feature extraction capability of CNNs with the powerful contextual understanding of Transformers. This synergy significantly improves detection accuracy, robustness, and reliability in challenging environments.

As autonomous systems continue to evolve, Hybrid CNN-Transformer architectures are expected to play a crucial role in enabling safer transportation, smarter cities, and more intelligent vision-based applications for the future.

ADVERSE WEATHER CONDITIONS



FOG



RAIN



SNOW

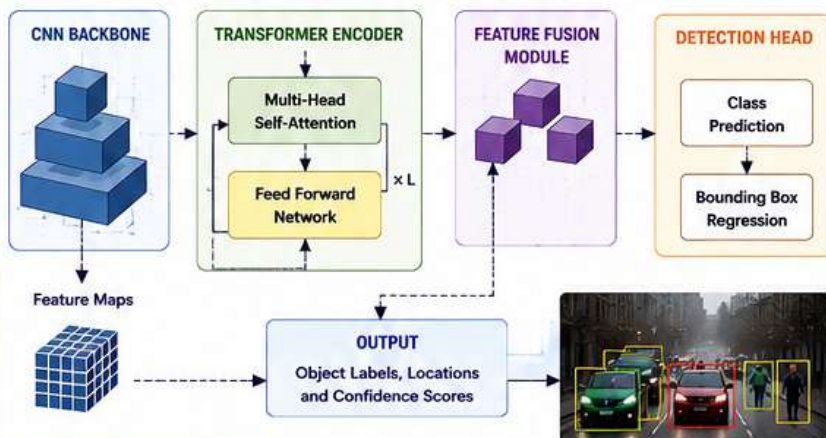


HAZE



LOW-LIGHT

5. HYBRID CNN-TRANSFORMER NETWORK



WORKING PRINCIPLE

- 1 Input image captured under adverse weather conditions.
- 2 CNN backbone extracts spatial features.
- 3 Transformer encoder analyzes global dependencies.
- 4 Feature fusion module combines local and global information.
- 5 Detection head identifies and classifies objects in real time.
- 6 Output includes object labels, locations, and confidence scores.



This hybrid approach significantly improves detection performance while maintaining real-time processing capability.

6. APPLICATIONS



AUTONOMOUS VEHICLES

Detect vehicles, pedestrians, cyclists, and road signs under fog, rain, and nighttime conditions.



SMART TRAFFIC MANAGEMENT

Monitor traffic flow and identify incidents during adverse weather.



INTELLIGENT SURVEILLANCE

Enhance public safety through reliable object detection in challenging environments.



INDUSTRIAL AUTOMATION

Enable robotic systems to operate accurately in outdoor industrial settings.



DRONE NAVIGATION

Support aerial monitoring and autonomous drone operations under varying weather conditions.



SMART CITIES

Provide weather-resilient monitoring systems for urban infrastructure and public services.

7. FUTURE SCOPE



Future research aims to integrate advanced attention mechanisms, multimodal sensors, and edge AI computing with Hybrid CNN-Transformer Networks. Combining visual data with radar, LIDAR, and thermal imaging can further enhance detection reliability.

Additionally, emerging technologies such as Federated Learning and Explainable AI can improve privacy, adaptability, and transparency in intelligent vision systems. The integration of lightweight Transformer architectures will also enable deployment on resource-constrained embedded devices.



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ECE EVENTS

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

WAVES

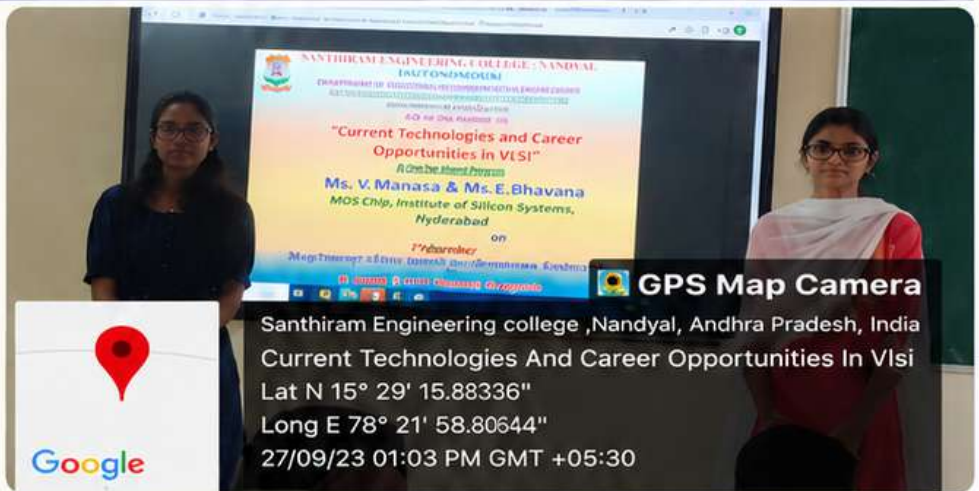
1. FACULTY DEVELOPMENT PROGRAM

A one-week faculty development program on **"Recent Trends in VLSI Technologies and Practical Approaches towards IP Using EDA Tools"** in association with JNTUA was conducted by the Department of ECE from **9-13 Oct, 2023**. The resource persons were from reputed institutes and industries. A total of 30 faculty members have attended this program.



2. ALUMINI PROGRAM

A one-day program on **"Current Technologies and Career Opportunities in VLSI"** was conducted by Department of ECE on **September 27, 2023**. Ms. V. Manasa and Ms. E. Bhavana, MOS Chip Institute of Silicon Systems, Hyderabad, acting as resource persons. A total of 240 Students have attended this program.



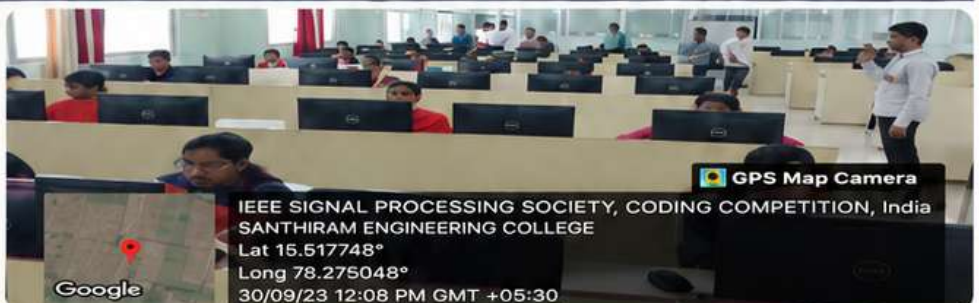
3. CAREER GUIDANCE PROGRAMS

A webinar on **"recent trends and challenges in VLSI and career opportunities"** was conducted by Department of ECE on 5th October, 2023.



4. TECHNICAL EVENT

Mrs. B. Alekya Himabindu conducted an online coding competition in association with IEEE Signal Processing Society, organized by Department of ECE on 30 Sep, 2023. A total of 110 Students have participated in this competition.



5. WORKSHOP PROGRAM

A Three-day workshop on **"Innovation on Industrial IoT and Automation"** was conducted by the Department of ECE from **November 23-25, 2023**. Mr. U. Kumar, Silicon Touch Technologies (TV Vijayawada), as a resource person. A total of 125 Students have trained in this program.





DEPARTMENT GALLERY

ELECTRONICS & COMMUNICATION ENGINEERING

WAVES

SREC TECHNICAL MAGAZINE

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ACADEMIC YEAR
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