EEE 4861 Assignment

Design and Investigation of a Simple Sensor Circuit Intended for Smart Food Packaging on Biodegradable Packaging

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Submitted to,

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Motivation: In Bangladesh, many food and daily grocery items lack proper packaging, leading to issues such as post-harvest losses and compromised food safety. Smart food packaging offers a solution by integrating sensor systems that provide early alerts about food quality. This not only enhances food safety and extends shelf life but also improves traceability and transparency, promotes greater consumer engagement, and supports sustainability through reduced waste.

Objective and CEP statement: Individuals or groups of up to three students will design and investigate a simple sensor circuit intended for smart food packaging on biodegradable packaging.

- ✓ The sensor circuit must be implemented using the Electrical and Electronic Engineering knowledge and all the modern tools studied in the class: SPICE simulator, stick diagram, layout design, and performance analysis using SPICE.
- ✓ A key component of the assignment is the submission of a detailed proposal that includes a thorough literature review and the selection of a suitable biodegradable plastic packaging material.
- ✓ The assignment must include a proposal to demonstrate how the designed sensor circuit can be integrated into the chosen biodegradable packaging to monitor food quality over time, thereby addressing food safety and environmental concerns.
- ✓ Additionally, students must propose a structured decision-making algorithm or framework that supports actions prioritizing food safety, human well-being, and sustainable practices under the Bangladesh Environmental Conservation Rules 2023(4).
- ✓ A comprehensive design report must be submitted upon completion of the assignment.

Critical Challenges: A common engineering practice is only the use barcode on the conventional plastic package to calculate product bill during payment. Conventional plastic packaging will not be used as they pollute the environment. Also, use of environmental-friendly electronic circuit system will enhance quality of life on earth.

Conflicting Requirements: Students are required to explore various design methodologies to evaluate potential solutions although such expensive biodegradable packaging with smart sensor system is difficult to integrate in a low-income country. Also, a lack of health safety knowledge is also one of the key constrains to implement the proposed system.

1. Course Outcomes (COs): EEE 4861 (VLSI Design)

CO4: Engage in independent research with regards to emergent topics in VLSI domain.

CO5: Consider safety and health issues in design of food packaging on biodegradable packaging.

2. Program Outcomes (POs): EEE 4861 (VLSI Design)

PO5: (Modern tool usage) Create, select and apply appropriate techniques, resources, and **modern engineering and IT tools**, including prediction and modelling, to complex engineering problems (CEP), with an understanding of the limitations. (K6)

PO7: (Environment and Sustainability) Understand and evaluate the **sustainability** and impact of professional engineering work in the solution of complex engineering problems in societal and **environmental** contexts. (K7).

3. We explore how a few Complex Engineering Problems (Ps) through this assignment:

P1: This assignment requires depth of Electrical and Electronic Engineering knowledge (K3) and also requires study of existing smart food packaging models with similar Goal (K8).

P2: Conflicting technical requirements: Plastic packaging is available, however, biodegradable plastic packaging are expensive with challenges in sensor system integration onto it (K5, K6). A low price variant is critical to achieve.

P3: No obvious or specific sensor circuit. A Ring oscillator, inverter, even voltage divider circuit can be a temperature sensor, some other circuits exhibits performance variation in the presence of O_2, N_2 and even under toxic environment (K4).

P4: Electrical and Electronic Engineering students are not typically study to issues related to bio-safety and food safety.

4. Knowledge Profiles (Ks) through this assignment:

- ✓ We accumulate **K3~K8.**

5. Complex Engineering Activities (As) through this assignment:

- ✓ We claim no Complex engineering activity from this assignment.

CO-PO-K-P-A Mapping: for CEP

COs	POs	Knowledge Profile(s)	CEP	CEA
CO4	**PO5**	**K6**	**P1, P2, P3, P4**	**-**
CO5	**PO7**	**K7**	**-**	**-**

6. **Rubrics for Assessment: (75 marks)**

Sl.	Section	Description	Marks
01.	**Literature Review & Material Selection (CO4, PO5)**	-Thorough literature review on sensor circuits for food packaging. -Selection and justification of suitable biodegradable plastic packaging material.	**10**
02.	**Sensor Circuit Design & Tools Usage (CO4, PO5)**	-Application of EEE knowledge in design. -Proper use of SPICE simulator, stick diagram, layout design. - Performance analysis using SPICE.	**20**
03.	**Integration with Packaging (CO5, PO7)**	-Proposal on integrating the designed sensor into biodegradable packaging. -Practical considerations for monitoring food quality over time.	**10**
04.	**Decision-Making Algorithm / Framework (CO5, PO7)**	-Structured decision-making method for prioritizing food safety, human well-being, and sustainability. -Alignment with Bangladesh Environmental Conservation Rules 2023(4).	**10**
05.	**Proposal Quality and originality (CO4, PO5)**	-Clarity, technical depth, and feasibility of the initial proposal. -Logical flow and completeness.	**10**
06.	**Final Design Report (CO4, PO5)**	- Comprehensive and well-organized documentation. -Includes all results, design files, simulations, and conclusions. - Clear communication of work. - Creativity, innovation, and originality in approach.	**15**

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Abstract

This report investigates a biodegradable and food safety compatible solution for food packaging addressing the challanges in Bangladesh. It designs a MOSFET based sensor circuit ti smart food packaging using biodegradable materials. Bangladesh, despite pioneering plastic bag ban in 2002, still suffers from the use conventional plastic packaging due to lack of affordable alternatives and poor enforcement mechanisms. This study conducts a comprehensive literature review of biodegradable packaging materials and identifies the Sonali Bag®, a cellulose-based biopolymer derived from jute, as an optimal solution for Bangladesh's context.

The Sonali Bag® offers significant advantages including indigenous technology developed by Bangladeshi scientists, economic viability with production costs of Tk. 1200 per kg compared to imported alternatives costing Tk. 2000-3000 per kg, and complete biodegradation within 100 days. The research proposes integrating a temperature sensor circuit into the Sonali Bag® packaging to monitor food quality and prevent spoilage of perishable items like fish, meat, milk, and vegetables.

The proposed sensor circuit employs a simple design using a temperature sensor placed inside the packaging, connected to a MOSFET-based switching circuit that activates an external LED or buzzer when temperature exceeds safe thresholds. This integration maintains the biodegradable properties of the packaging while adding smart functionality for food safety monitoring. The circuit design will be implemented and analyzed using SPICE simulation tools, stick diagrams, and layout design to ensure optimal performance.

This approach addresses the complex engineering challenges of combining biodegradable packaging with sensor technology in a cost-effective manner suitable for Bangladesh's low-income market context. The integration proposal demonstrates how modern electronic engineering knowledge can be applied to create sustainable solutions that prioritize food safety, human well-being, and environmental conservation in alignment with Bangladesh Environmental Conservation Rules 2023.

1. Literature Review

1.1 Biodegradable Food Packaging System: Bangladesh Context

Bangladesh has been the pioneering country in imposing a nationwide ban on polythene bags in 2002, with renewed enforcement measures introduced in 2024. But the field reality is very different. Weak enforcement mechanisms and the lack of scalable, cost-effective alternatives have allowed conventional plastic to persist in markets.

From literature[1], around three-quarters (74%) of retailers in southwestern Bangladesh still provide plastic bags to customers, and only 4% offer environmentally friendly jute bags. This suggests the ban has been largely ineffective in changing actual scenario. The root cause can be identified as:

- **Lack of Alternatives**: The primary reason for continued plastic bag use is the unavailability of suitable alternatives. Retailers and consumers find plastic bags cheap, lightweight, and convenient.
- **Poor Enforcement**: Government raids and monitoring visits are infrequent and insufficient. The study found that shops located farther from main roads are more likely to violate the ban, suggesting retailers can easily evade enforcement.
- **Limited Awareness**: Surprisingly, 73% of respondents lacked knowledge about the plastic bag ban, despite it being in effect for nearly two decades. This awareness gap significantly contributes to widespread non-compliance.
- **Consumer Demand**: Most consumers (55%) never restrict retailers from providing plastic bags, indicating low environmental consciousness among the public.

This reality emphasizes that, only legal regulation is not enough for moving to biodegradable solutions. Cost friendly and scalable alternative product availability is a crucial requirement.

1.2 Available Biodegradable Packaging Solutions

The literature[2][3] reveals a diverse range of biodegradable packaging materials that could potentially address Bangladesh's plastic pollution challenges. These materials can be categorized into three main groups: synthetic biodegradable polymers, natural biopolymers extracted from biomass, and polymers produced by microorganisms.

Comparative Analysis of Biodegradable Packaging Materials

Based on comprehensive research analysis, the following comparison table presents key biodegradable packaging options with costs converted to BDT.

Material	Weight	Cost (BDT)	Primary Advantages	Key Limitations	Biodegradation Time
Mushroom Packaging	50-70g	16-27	Grown from agricultural waste, fully biodegradable, strong and durable	Longer production time, higher cost, limited scalability	30-90 days
Bamboo Fiber	30-50g	11-16	Rapidly renewable, biodegradable, strong and lightweight	Higher cost than paper, requires careful sourcing	4-6 months
Algae-Based	10-20g	22-32	Fast growth, edible and biodegradable, low carbon footprint	Limited shelf life, very high production cost	2-5 weeks
Sugarcane Fiber	40-60g	5-9	Byproduct utilization, biodegradable and compostable, low cost	Bulkier than plastic, limited moisture resistance	60-90 days
Coconut Husk Fiber	30-45g	9-13	Made from waste product, biodegradable, strong and durable	Higher cost than paper, limited availability	6-12 months
Wheat Straw	35-50g	6-11	Agricultural byproduct, biodegradable, very low cost	Limited applications, less durable	3-4 months
PLA (Polylactic Acid)	10-15g	11-22	Similar to plastic functionality, compostable under industrial conditions	Requires specific composting facilities, higher cost	3-6 months (industrial)

Starch-Based	10-70g	5-32	Excellent gas barrier, abundant availability, edible, low cost	Brittle, water susceptible	20-40 days
Chitosan	Variable	Variable	High antimicrobial properties, biodegradable, biocompatible	Low water barrier properties	1-6 months
Cellulose	20-40g	8-15	Abundant natural resource, recyclable, biodegradable, good printability	Moisture sensitive, limited barrier properties, moderate strength	2-5 months

Material Categories and Applications

Natural Fiber-Based Solutions: Materials like bamboo fiber, coconut husk, and wheat straw represent agriculturally-derived options that uses existing waste streams. These materials offer good mechanical properties but vary significantly in cost and availability.

Starch-Based Packaging: Derived from potato, rice, maize, and wheat, starch-based materials provide excellent gas barrier properties and complete biodegradability. However, their susceptibility to moisture limits certain applications.

Protein-Based Solutions: Including soy protein, wheat gluten, casein, and gelatin-based films, these materials offer good film-forming properties and nutritional compatibility but generally exhibit poor water resistance.

Synthetic Biodegradable Options: PLA represents the most commercially viable synthetic biodegradable option, offering plastic-like functionality while maintaining biodegradability under proper composting conditions.

Performance Characteristics Comparison

The research reveals significant trade-offs between different materials:

- **Cost Effectiveness:** Wheat straw and sugarcane fiber emerge as the most economical options (6-11 BDT), while algae-based materials represent the premium segment (22-32 BDT).
- **Mechanical Properties:** Mushroom packaging and bamboo fiber demonstrate superior

strength and durability compared to starch-based alternatives.

- **Environmental Impact:** All materials show significant environmental benefits over conventional plastics, with biodegradation times ranging from 2 weeks (algae-based) to 12 months (coconut husk).
- **Scalability Challenges:** Materials like mushroom packaging and algae-based solutions face significant scalability limitations due to production complexity and resource requirements.

Market Readiness Assessment

The literature indicates that while numerous biodegradable alternatives exist, their market penetration remains limited due to cost premiums, performance gaps, and infrastructure requirements. Starch-based and PLA materials show the highest commercial readiness, while innovative solutions like mushroom packaging require further development for mass market applications.

This comprehensive analysis provides the foundation for selecting appropriate biodegradable packaging solutions that can address Bangladesh's specific market needs while considering cost effectiveness, performance requirements, and environmental impact.

1.3 The Bangladesh Perspective and Selection of Sonali Bag®

In Bangladesh perspective, extensive research work have been done on Jute (cellulose) based Sonali Bag. There have been alternatives, such as Polka Bags from potato starch, Corn Starch bags and others- however, they lack extensive research and scalability as of yet.

While numerous biodegradable alternatives exist globally, the Bangladesh context requires a solution that addresses the specific implementation challenges identified in Section 1.1. Among available options, the Sonali Bag emerges as the optimal choice for Bangladesh's biodegradable packaging transition.

Bangladeshi Technology: The Sonali Bag, a cellulose-based biopolymer derived from jute, was invented by Bangladeshi scientists Dr. Mubarak Ahmad Khan and his team. This is the result of over two decades of dedicated research, utilizing the existing expertise in jute processing rather than requiring foreign technology.

Economic Viability: Production costs of Tk. 1200 per kg compared to imported biodegradable films priced at Tk. 2000-3000 per kg demonstrate substantial cost advantages. Established facilities can generate annual profits of Tk. 288.29 million while eliminating import costs and currency risks.

Raw Material Security: Bangladesh's position as a major jute producer ensures sustainable availability. Jute provides supply chain security while creating additional value for agricultural communities.

Performance Characteristics: Research demonstrates complete biodegradation within 100 days with no toxic residue, water absorption capacity of 1.45% ideal for agricultural applications, thermal stability up to 250°C, and controlled degradation based on environmental conditions.

Implementation Advantages: Sonali Bag addresses Section 1.1 challenges through locally manufactured scalable solutions, competitive pricing for retailers, familiar jute-based origin reducing consumer resistance, and viable alternatives strengthening policy enforcement.

While other Bangladeshi alternatives exist (Polka Bags, corn starch bags), these lack extensive research validation and scalability. Sonali Bag offers established research documentation, proven manufacturing processes, and government institutional support.

The selection represents optimal alignment of Bangladesh's agricultural resources, scientific capabilities, and environmental objectives, positioning the country as a regional leader while addressing domestic challenges and creating economic opportunities in the jute sector.[4]

2. Design of Sensor Circuit

2.1 Sensor Selection

The selection of appropriate sensors for smart biodegradable packaging systems represents a critical design decision that directly impacts food quality monitoring effectiveness. This analysis evaluates sensor technologies suitable for integration with biodegradable packaging materials to address Bangladesh's food safety challenges.

Sensor Technology Options

pH Indicators

Colorimetric sensors utilizing natural pigments (anthocyanins) detect food acidity changes through visual color transitions. While cost-effective and locally sourced, these sensors exhibit limited specificity and environmental sensitivity.

Gas Indicators

Volatile compound detection systems monitor spoilage-related gases (CO2, H2S, NH3). Despite high specificity for microbial contamination, these sensors require complex calibration and demonstrate cross-sensitivity issues.

Time-Temperature Indicators (TTIs)

Thermal history monitoring systems provide cumulative temperature exposure assessment through irreversible color changes. However, TTIs offer only indirect food quality correlation and limited ambient temperature effectiveness.

Electronic Temperature Sensors

Precision temperature monitoring using complementary sensing architectures enables accurate thermal tracking with digital output capabilities.[5]

Selected Solution: Complementary Temperature Sensor

The electronic temperature sensor addresses critical cold chain monitoring requirements in Bangladesh's tropical climate, where temperature excursions significantly impact food safety and quality retention.

Integration Advantages

The proposed temperature sensor employs an **all-MOSFET-based implementation** that prioritizes silicon area efficiency and manufacturing simplicity. This architectural approach delivers significant spatial advantages, requiring only **0.0018 mm²** in standard 180nm CMOS technology for the core sensing elements, with total fabricated area including reference circuitry measuring **0.013**

mm².

Traditional BJT-based temperature sensors demonstrate widespread acceptance due to their accurate temperature sensing capabilities, typically achieving accuracy below ±1°C. However, the all-MOSFET design achieves comparable performance with **absolute temperature inaccuracy of less than ±0.6°C without calibration**, making it suitable for general-purpose applications including room monitoring, automotive systems, and refrigeration temperature control.

The MOSFET implementation leveraging subthreshold operation provides multiple operational benefits:

- **Ultra-Low Power Operation:** Power consumption of only **40 nW at 1.2V supply voltage** meets stringent requirements for wireless sensor node applications and enables extended battery-free operation through energy harvesting integration.
- **Calibration-Free Implementation:** Eliminates production calibration requirements, significantly reducing manufacturing time and ongoing maintenance costs while ensuring consistent performance across production batches.
- **Rapid Response Characteristics:** Threshold voltage-based temperature sensing mechanism enables fast thermal response, supporting real-time monitoring applications critical for food safety assessment.

This MOSFET-based sensor architecture aligns with moderate accuracy requirements while providing exceptional power efficiency and integration compatibility, making it particularly suitable for distributed sensing applications in smart packaging systems where multiple sensors must operate continuously with minimal power consumption.

Economic Feasibility

While requiring initial semiconductor investment, the sensor's calibration-free operation and high accuracy reduce manufacturing complexity and quality control costs, supporting scalable deployment across Bangladesh's food packaging industry.

2.2 Complementary Temperature Sensor Workflow

This temperature sensor uses **two complementary sensing cores** that generate opposite thermal behaviors, then calculates temperature by taking their difference to achieve high accuracy.

Core Components

1. Reference Current Generator

- Resistor-less beta multiplier circuit provides stable reference current
- Current exhibits PTAT (Proportional-To-Absolute-Temperature) behavior
- Powers both sensing cores

2. CTAT Sensor (Complementary-To-Absolute-Temperature)

- Uses NMOS transistors operating in subthreshold region
- Output voltage **decreases** as temperature increases
- Dominated by threshold voltage temperature coefficient (-0.63 mV/°C)
- Achieves -2.1 mV/°C thermal slope

3. PTAT Sensor (Proportional-To-Absolute-Temperature)

- Uses PMOS transistors in similar subthreshold configuration
- Output voltage **increases** as temperature increases
- Supply-dependent but compensated by differential operation

Operating Principle

Temperature Calculation:

Temperature $\propto (V_{PTAT} - V_{CTAT})$

Key Advantages:

- **Calibration-free**: Differential operation cancels process variations
- **High accuracy**: ±0.6°C over -40°C to +85°C range
- **Ultra-low power**: 40 nW at 1.2V supply
- **Small footprint**: 0.013 mm² in 180nm CMOS

Signal Processing

- Both sensors output analog voltages
- External ADCs digitize each signal
- Microcontroller calculates temperature from voltage difference
- Linear relationship enables direct temperature conversion

Block Diagram:

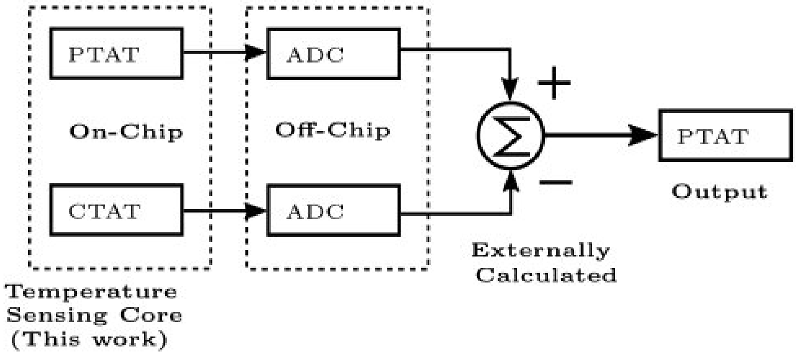

Fig. 1 Block diagram of proposed temperature circuit

Schematic:

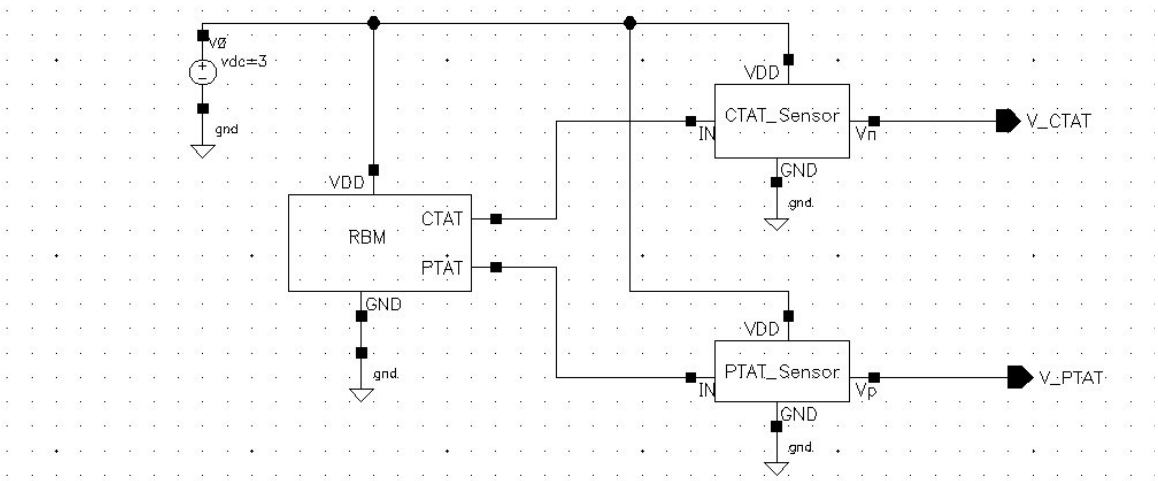

Fig. 2 Circuit diagram of temperature sensing module

Resistorless Beta Multiplier (RBM) Subcircuit:

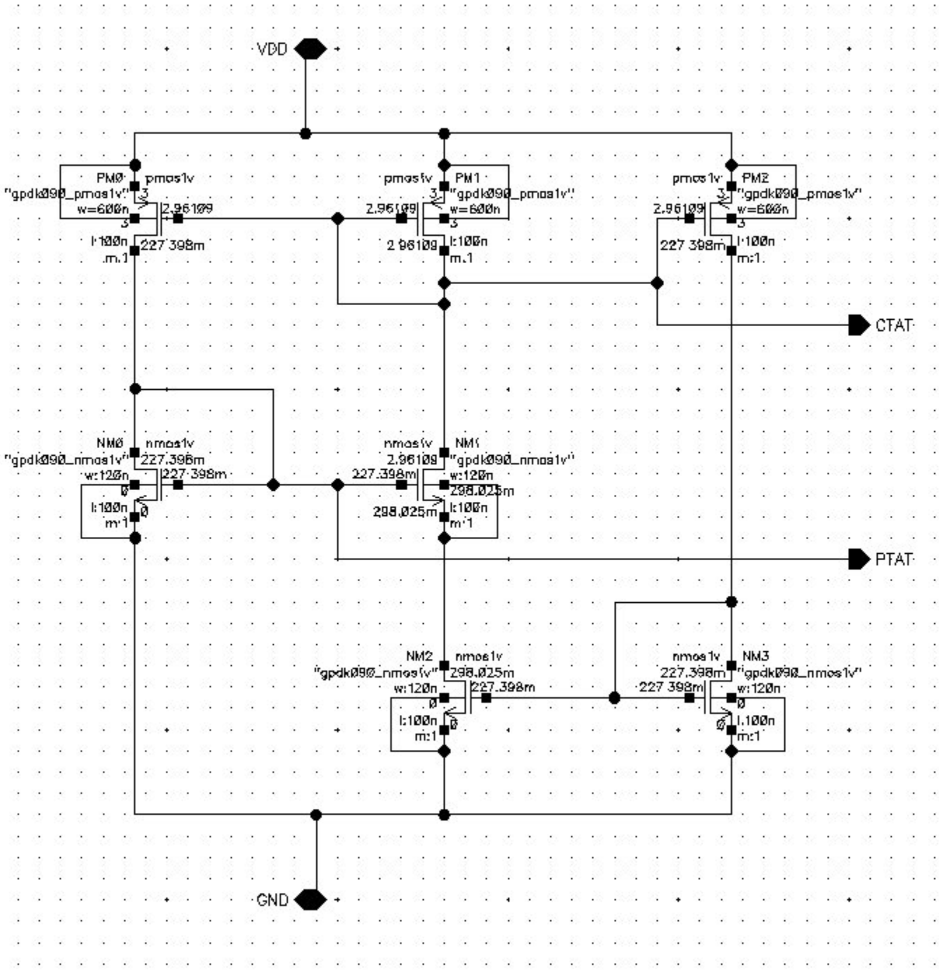

Fig. 3 Resistorless Beta Multiplier (RBM) Subcircuit

Stick Diagram (RBM):

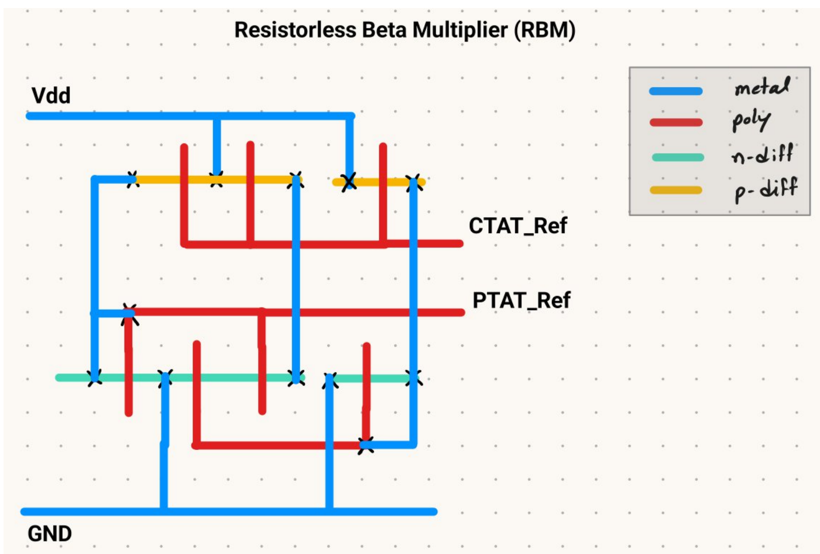

Fig. 4 Stick Diagram of RBM Subcircuit

Layout Diagram (RBM):

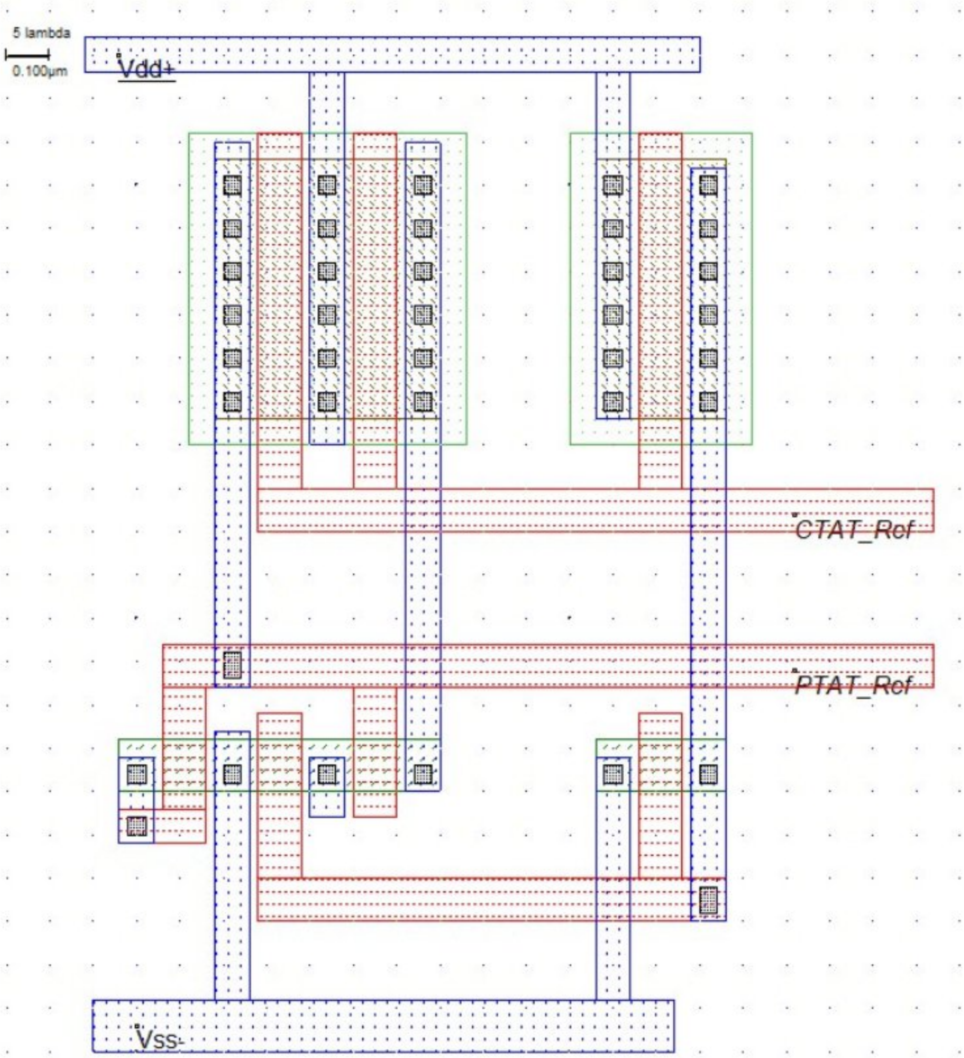

Fig. 5 Layout Diagram of RBM Subcircuit

Proportional-To-Absolute-Temperature (PTAT) Subcircuit:

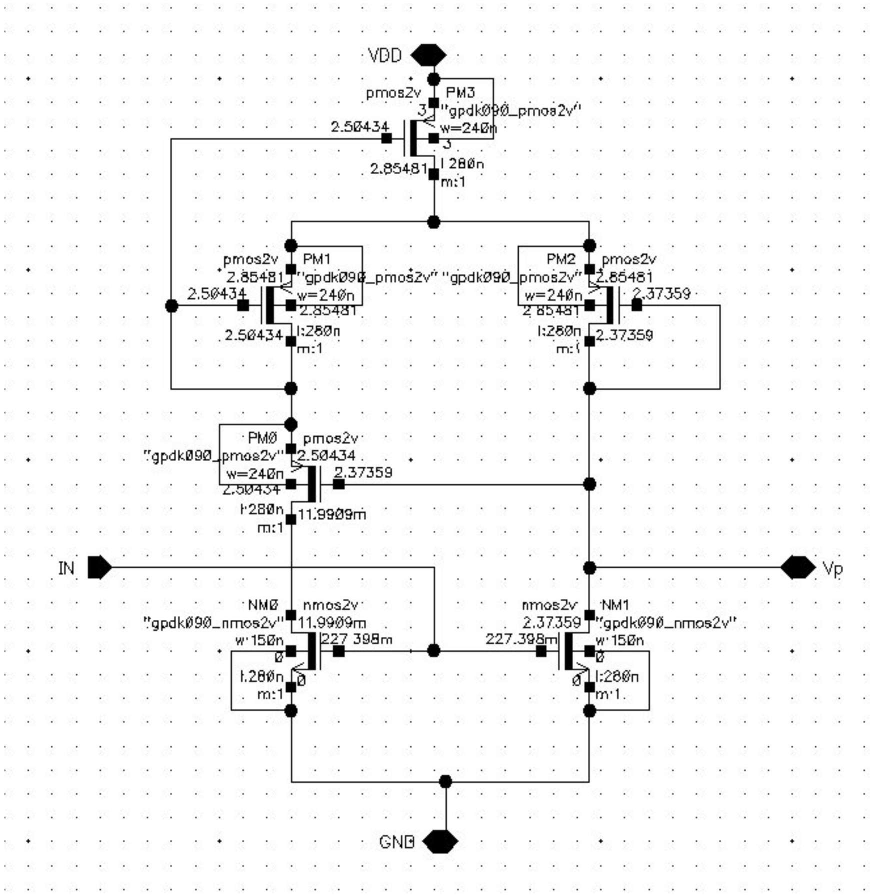

Fig. 6 Proportional-To-Absolute-Temperature (PTAT) Subcircuit

Stick Diagram (PTAT):

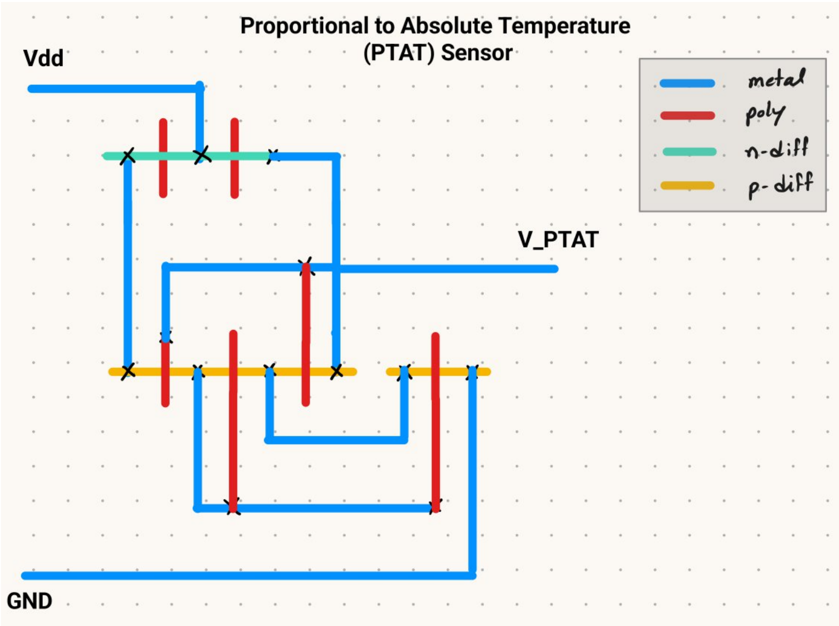

Fig. 7 Stick Diagram of PTAT Subcircuit

Layout Diagram (PTAT):

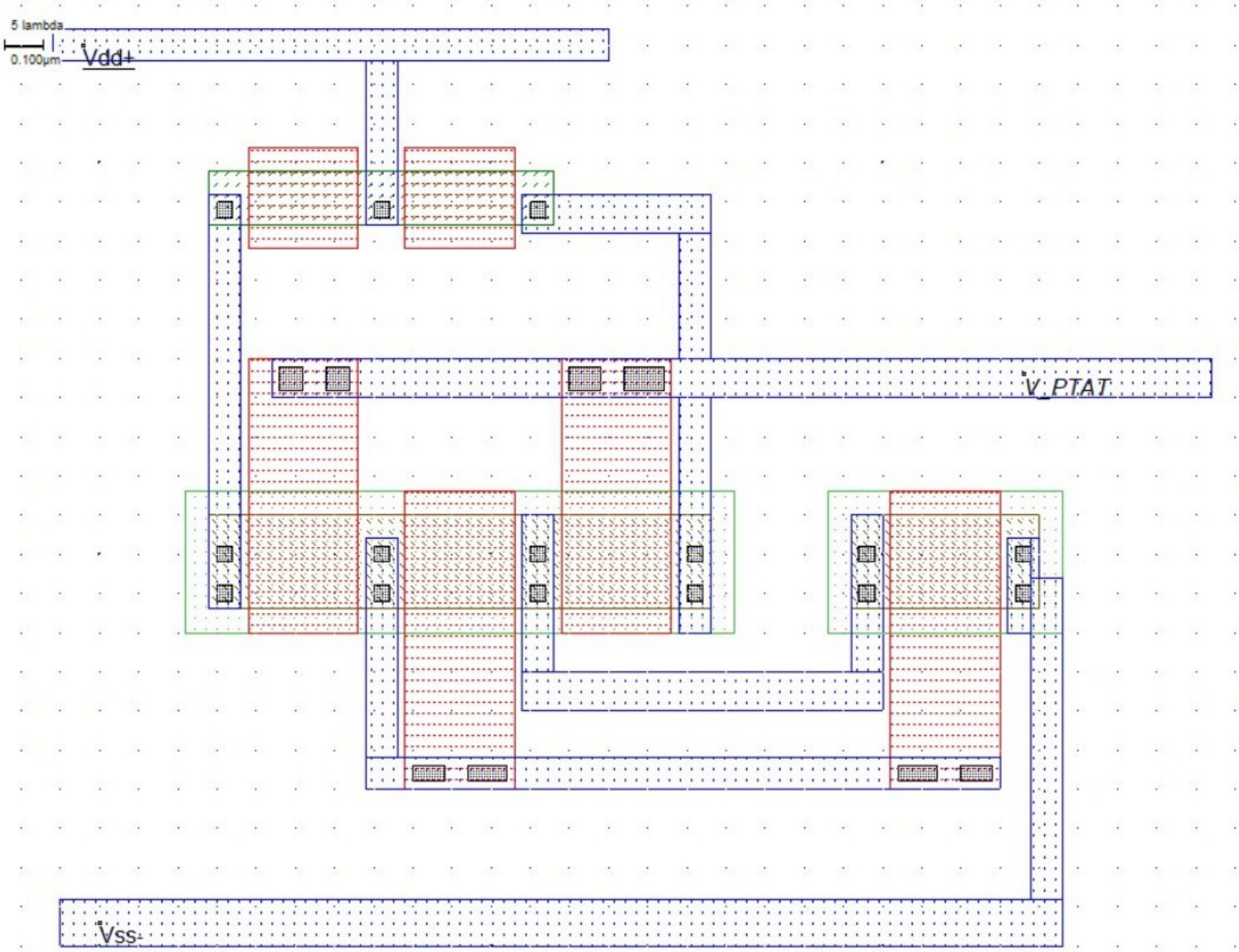

Fig. 8 Layout Diagram of PTAT Subcircuit

Complementary-To-Absolute-Temperature (CTAT) Subcircuit:

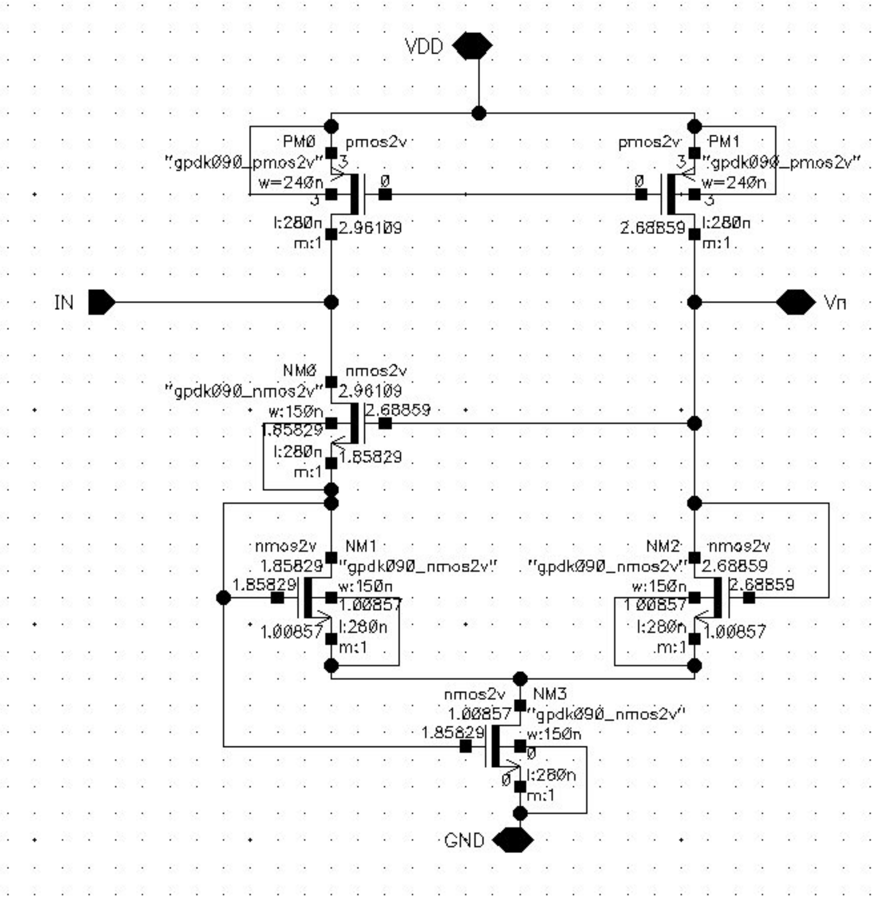

Fig. 9 Complementary-To-Absolute-Temperature (CTAT) Subcircuit

Stick Diagram (CTAT):

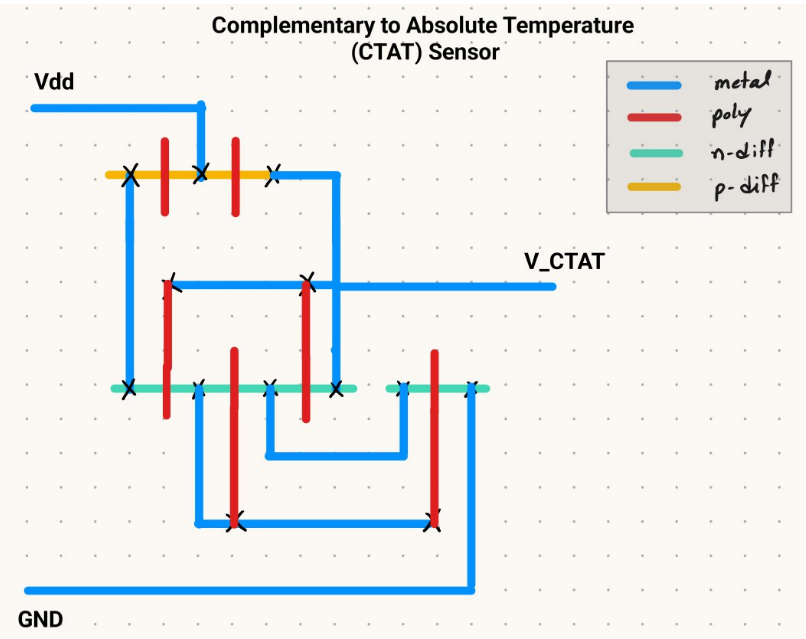

Fig. 10 Stick Diagram of CTAT Subcircuit

Layout Diagram (CTAT):

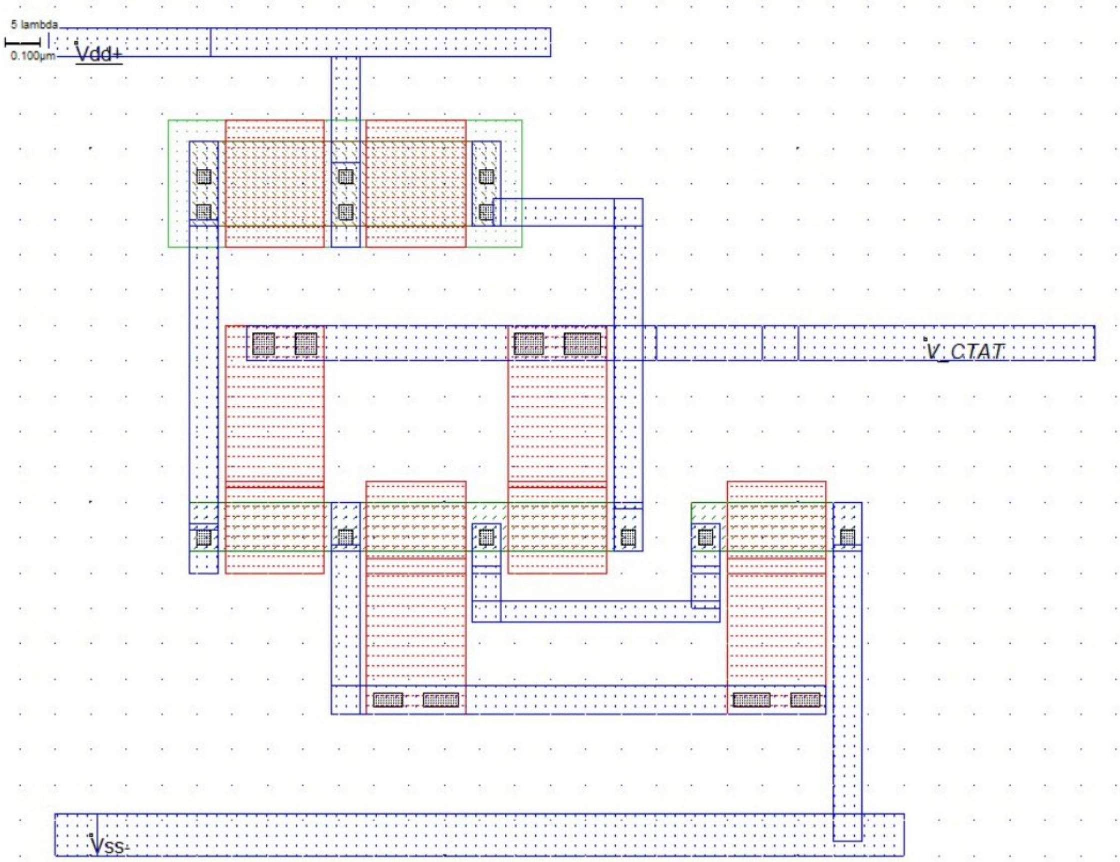

Fig. 11 Layout Diagram of CTAT Subcircuit

2.3 Sensor Output

PTAT Output:

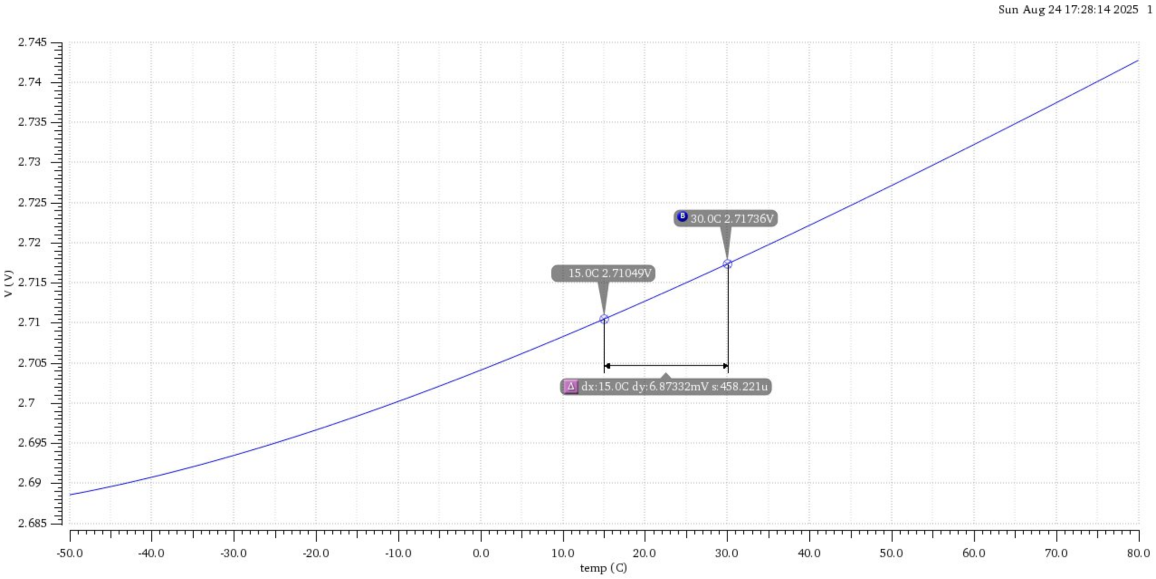

Fig. 12 Proportional-To-Absolute-Temperature (PTAT) Output

CTAT Output:

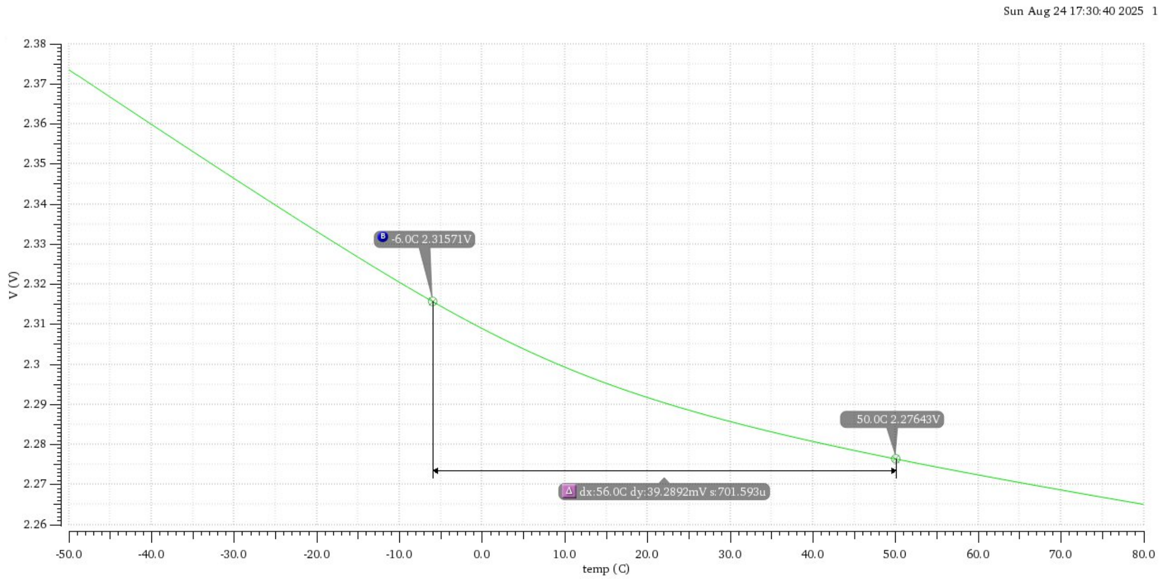

Fig. 13 Complementary-To-Absolute-Temperature (CTAT) Output

Final Output:

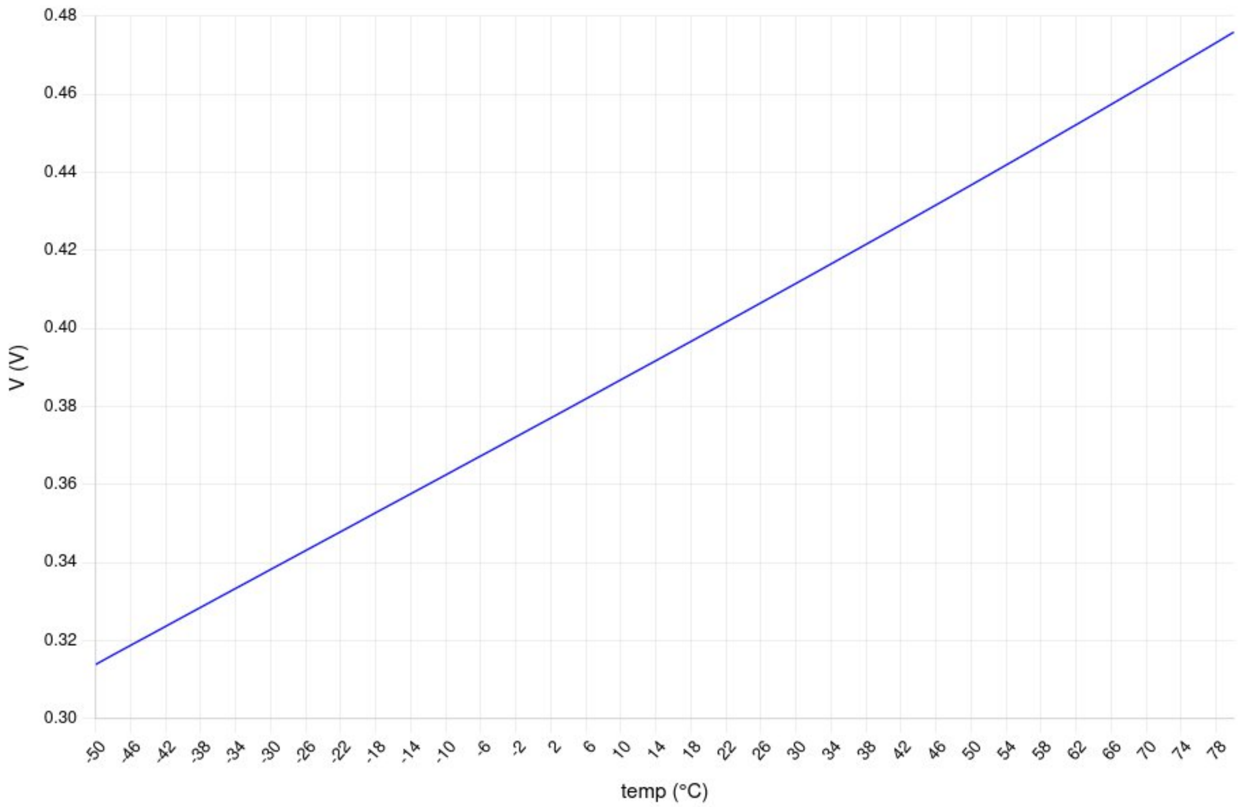

Fig. 14 Temperature Sensor Differential Output

3. Integration of Sensor Circuit into Biodegradable Packaging

3.1 Temperature Sensor Circuit as a Measure of Food Safety

Food products requires optimal environment for maintaining quality. Perishable foods like fish, meat, milk, and vegetables can spoil if exposed in a high temperature. Integrating a temperature sensor to our biodegradable Sonali Bag packaging allows to get notified and take measure if temperature is above safe range.

3.2 Proposal of Integrating Temperature Sensor to Sonali Bag

We propose a simple threshold detection circuit that continuously monitors food temperature inside the Sonali Bag packaging. The circuit uses a temperature sensor connected to a MOSFET-based switching system that activates external alerts when temperature thresholds are exceeded.

Circuit Components and Operation: The temperature-activated switching circuit consists of a temperature sensor, MOSFET as voltage-controlled switch, current-limiting resistor for protection, and LED/buzzer for user notification. When the sensor detects temperature above a threshold, it triggers the MOSFET to switch on, completing the circuit path and activating the alert indicator.

Multi-Level Alert System: The circuit provides graduated responses based on temperature conditions:

- **Normal Status:** No alert when temperature remains within safe range for specific food types
- **Warning Level:** Blinking LED activation when temperature approaches critical threshold
- **Alert Level:** Steady LED light when temperature exceeds safe limit requiring attention
- **Critical Level:** Buzzer activation for extended temperature exposure indicating potential food spoilage

Physical Integration Strategy: The temperature sensor will be embedded with the Sonali Bag material for direct food environment monitoring, while the LED/buzzer indicators will be mounted on the outer surface for clear consumer visibility. This design protects electronic components from moisture and contamination while ensuring the alert system remains accessible and user-friendly.

Implementation Benefits: This threshold detection circuit maintains the biodegradable properties of the Sonali Bag with food safety monitoring capabilities added. The comparator-based design uses basic electronic components, making it cost-effective for implementation in Bangladesh's market context. The multi-threshold detection system helps consumers understand the urgency level and take appropriate action to prevent food spoilage and potential health risks.

4. Decision-Making Algorithm and Framework

This section explains a simple decision-making process that puts food safety first, protects people's health, and follows Bangladesh's environmental rules.

4.1 The Decision System Workflow

The system works in simple steps:

Step 1: Always Watching The temperature sensor keeps checking the temperature inside the bag. Different foods have different safe temperatures - milk and fish need to stay colder than vegetables.

Step 2: When Something Goes Wrong If the temperature gets too high, the sensor turns on the LED light or buzzer. This tells people that the food might not be safe anymore.

Step 3: What People Should Do When the alert goes off, people can follow this simple guide:

- **If the food was warm for less than 2 hours**: It's probably still okay to eat right away or put in the fridge quickly
- **If the food was warm for more than 2 hours**: It's better to throw it away safely
- **When throwing away**: Put the food and the biodegradable bag in compost or organic waste

4.2 Important Considerations

The system follows this order of importance:

1. **People's Health** (Most Important)
   - Keep people safe from food poisoning
1. **Environment** (Second Most Important)
   - Use biodegradable packaging that doesn't harm nature
   - Reduce food waste by catching problems early
1. **Cost** (Third Most Important)
   - Keep the system affordable for Bangladeshi families

4.3 Following Bangladesh Environmental Rules

Our system follows Bangladesh Environmental Conservation Rules 2023 in these ways:

Better Waste Management:

- Sonali Bag packaging breaks down naturally without polluting
- Less food gets wasted because we catch problems early
- Small electronic parts can be disposed of safely

Less Pollution:

- No plastic bags harming the environment

- Less rotting food in landfills creating harmful gases
- Encourages people to buy only what they need

Designed for Bangladesh
The system is designed for how people actually live and shop in Bangladesh:

- Simple lights and sounds that anyone can understand
- No need for smartphones or complicated technology
- Good for both traditional markets and modern shops
- Helps keep food fresh from farm to kitchen
- Teaches people about keeping food at safe temperatures

4.4 Action Guide

Alert	What It Means	What To Do	How Fast
No Alert	Food is fine	Keep as normal	-
Light Blinking	Getting warm	Check food soon	Within 30 minutes
Steady Light/Buzzer	Too warm	Use quickly or throw away	Right away
Bright/Loud Alert	Dangerous	Don't eat, throw away safely	Immediately

4.5 Long-Term Plans

Starting Out (Next 2 Years):

- Try it in super shops first
- Teach people how to use it
- Make it cheaper to produce

Growing (2-5 Years Later):

- Bring it to village markets
- Maybe connect to mobile phones for more information
- Work with government programs

Future (5+ Years):

- Make even smarter sensors
- Help predict problems before they happen
- Maybe sell to other countries too

5. Conclusion

This project successfully addresses Bangladesh's dual challenges of food safety and environmental protection through the integration of smart sensor technology with biodegradable packaging. The comprehensive literature review identified the Sonali Bag as the optimal packaging solution, offering local production advantages at Tk. 1200 per kg compared to imported alternatives costing Tk. 2000-3000 per kg, while ensuring complete biodegradation within 100 days.

The proposed temperature-activated switching circuit provides a practical solution for food safety monitoring using simple, cost-effective components. The multi-level alert system (Normal, Warning, Alert, Critical) enables consumers to make informed decisions about food safety while the threshold detection circuit ensures immediate notification when temperature exceeds safe limits for perishable foods.

The integration of the sensor circuit into Sonali Bag packaging maintains environmental sustainability while adding intelligent functionality. The decision-making framework prioritizes human health, environmental protection, and economic viability, ensuring compliance with Bangladesh Environmental Conservation Rules 2023.

This approach demonstrates how modern electronic engineering knowledge can be applied to create sustainable solutions suitable for Bangladesh's market context. The combination of indigenous biodegradable packaging technology with smart sensor systems offers a scalable model for reducing food waste, preventing foodborne illness, and supporting environmental conservation goals.

The project establishes a foundation for future development of smart packaging systems in Bangladesh, with potential for expansion to rural markets and integration with mobile technology for enhanced food safety monitoring and traceability.

References

1. *Shawon, Ifthear & Haider, Mohammed & Oni, Fahmida. (2023). EFFECTIVENESS OF BANNING PLASTIC BAG IN BANGLADESH FOR ENVIRONMENTAL PROTECTION. Khulna University Studies. 112-118. 10.53808/KUS.SI.2023.ICES.A40-ss.*
2. *Panou, A.; Karabagias, I.K. Biodegradable Packaging Materials for Foods Preservation: Sources, Advantages, Limitations, and Future Perspectives. Coatings 2023, 13, 1176. https://doi.org/10.3390/coatings13071176*
3. *Gupta, Shipra and Bagdwal, Sweta and Agarwal, Shipra, A Comparative Study between Biodegradable and Plastic Waste Packaging Material (November 15, 2024). Proceedings of the 3rd International Conference on Optimization Techniques in the Field of Engineering (ICOFE-2024), Available at SSRN: https://ssrn.com/abstract=5086897 or http://dx.doi.org/10.2139/ssrn.5086897*
4. *Aftab, Hrithita & Samadder, Rajib & Rahman, Md & Ruhane, Tania & Khan, Mubarak. (2025). From crop to compost: Sonali Bag®—The biopolymer revolutionizing sustainable agriculture. Polymer Engineering & Science. 65. 1268-1282. 10.1002/pen.27074.*
5. *Sani, M.A.; Azizi-Lalabadi, M.; Tavassoli, M.; Mohammadi, K.; McClements, D.J. Recent Advances in the Development of Smart and Active Biodegradable Packaging Materials. Nanomaterials 2021, 11, 1331. https://doi.org/10.3390/nano11051331*