Detecting Ripe Fruit Using a Light-Dependent Visible Light Circuit with IRFZ44N MOSFET

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Abstract— Efficient detection of fruit ripeness is important in agriculture and food supply chains. It helps ensure product quality, reduce food waste, and allows for timely harvesting. Traditional methods that rely on manual inspection are subjective, inconsistent, and not practical for large-scale use. This work introduces a low-cost, portable electronic circuit that detects fruit ripeness by using reflected visible light. The circuit features a Light Dependent Resistor (LDR) set up with a voltage divider, an IRFZ44N N-channel MOSFET, and LED indicators. It identifies ripe fruits, which are usually red, by measuring light reflectivity. This provides real-time visual feedback. The proposed system is suitable for small farmers, vendors, and educational purposes. It offers a scalable, energy-efficient, and easy-to-use option for assessing ripeness.

Keywords—Fruit ripeness, IRFZ44N, LDR, visible light, MOSFET switching, analog circuit, smart agriculture, light reflection.

I. Introduction

The agriculture sector increasingly depends on technology to meet rising food demands while reducing waste and environmental impact. A key challenge in fruit production is figuring out the best time to harvest. This ensures freshness, minimizes spoilage, and keeps nutritional value. Ripeness is crucial for market quality, shelf life, and customer satisfaction. Farmers and retailers typically look at color, texture, and smell to assess ripeness. This process is labor-intensive and can lead to human error. Additionally, these methods are impractical for high-volume operations or remote areas. On the other hand, spectroscopic and computer vision solutions offer accuracy but are often too costly for many users. This project seeks to close this gap by providing an affordable, portable, and effective way to detect ripeness in real-time using visible light. and common electronic components. Our approach leverages the colour difference between ripe and unripe fruits—primarily the increased red reflectivity in ripe fruits—to activate an LED signal via an LDR-MOSFET circuit.

II. Background and Motivation

Fruit ripening involves complex biochemical processes. These include breaking down chlorophyll and creating pigments like anthocyanins and carotenoids. These changes show as visible colour shifts, usually from green to yellow, orange, or red. Photodetectors and optical circuits can detect these physical changes.

More than 30% of global food production is lost due to post-harvest issues, including misjudged ripeness. Many developing areas still rely on visual inspection, which is not scalable or consistently accurate. In contrast, electronic methods like hyperspectral imaging, spectrophotometry, and machine vision are costly, fragile, and require specialized knowledge.

This project aims to create a low-cost, easy-to-assemble, and user-friendly circuit. It will help small-scale producers and vendors assess fruit ripeness in real-time. The system uses an LDR to measure reflected light and a MOSFET to control an LED indicator, providing a straightforward yet effective solution for on-site ripeness evaluation.

III. Objectives

The primary objectives of this project are as follows:

• To design and build an electronic circuit that uses visible light to identify ripe fruits based on surface reflectance.

• To use basic electronic components like an LDR, resistors, LEDs, and a power-efficient IRFZ44N N-channel MOSFET.

• To provide a binary (LED ON/OFF) feedback system for detecting ripeness.

• To ensure that the solution is cost-effective, portable, user-friendly, and suitable for real-world agricultural use.

IV. Related Work

Previous research on fruit ripeness detection includes methods like near-infrared (NIR) spectroscopy, hyperspectral imaging, and machine vision using RGB and multispectral cameras. These techniques have shown high accuracy in commercial settings. For example, machine learning models trained on fruit colour datasets can classify ripeness levels with over 90% precision. However, their high costs, complex calibration, and maintenance needs limit their use in rural or resource-limited areas.

In contrast, simpler analog circuits have been proposed for educational and prototyping purposes. These circuits use photodiodes, LDRs, or colour sensors to detect changes in reflected light. Our project builds on these simpler methods by optimizing the component setup, focusing on affordability and durability without losing functionality.

V. Methodology

A. Principle of Operation

The circuit measures the intensity of reflected light from fruit surfaces, mainly in the red colour spectrum. Ripe fruits, like red apples or tomatoes, reflect more red light, which the LDR can capture when placed near the sample.

B. Circuit Design

The system includes the following components:

LDR (Light Dependent Resistor): This acts as a light sensor, with its resistance decreasing in bright light.

- **Voltage Divider:** Formed by the LDR and a 120kΩ resistor, generating a gate voltage for the MOSFET.
- **IRFZ44N N-Channel MOSFET:** This works as a switch. It turns ON when the gate voltage exceeds the threshold.
- **Two LEDs:** One is always ON to show power, and the other is controlled by the MOSFET to indicate ripeness. **Potentiometer (10kΩ):** This is used to calibrate sensitivity in different lighting situations.
- **Power Supply:** A 7.5V DC source powers the circuit.

C. Working Procedure

1. Place the fruit sample under a white LED or natural light source at a fixed distance.
2. The LDR senses the reflected light and changes its resistance.
3. The output from the voltage divider goes to the MOSFET gate.
4. When the threshold voltage is reached due to higher reflection, the MOSFET conducts and turns on the second LED.

This design ensures low power use, portability, and flexibility for field conditions.

VI. Simulation

Before building the physical model, a simulation was done using the Proteus Design Suite. The goal was to check:

- The correct switching behavior of the MOSFET.
- Stable voltage division under different light levels.
- The LED illumination logic is based on LDR values.

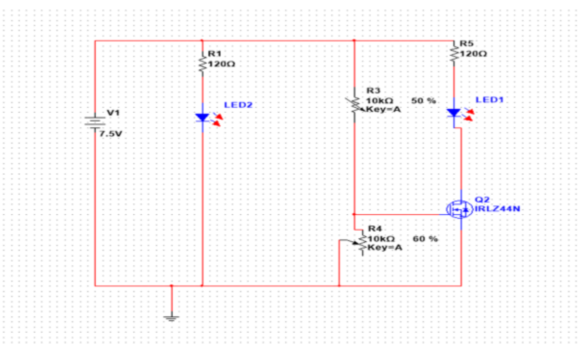

Figure 1: Simulation

The simulation confirmed the theoretical expectations. By changing the light intensity on the LDR, the MOSFET toggled the second LED, showing it was ready for hardware implementation.

VII. Hardware Implementation

The physical circuit was built on a breadboard using actual components. The following setup was used:

- One LDR was placed near the fruit sample.
- A 120kΩ resistor and potentiometer forming a voltage divider.
- Two LEDs with 120Ω resistors.
- One IRFZ44N MOSFET.
- A 7.5V battery power supply.
- A multimeter for checking voltage and debugging.

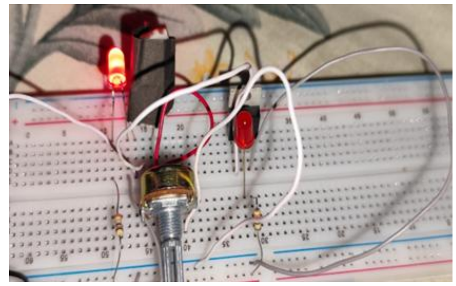

Figure 2: Hardware Implementation

Fruits like ripe tomatoes, bananas, and apples were tested. The system performed consistently when exposed to highly reflective, ripe surfaces.

VIII. Results and Discussion

A. Observations

- Ripe red fruits, like tomatoes, triggered the MOSFET and lit the LED.

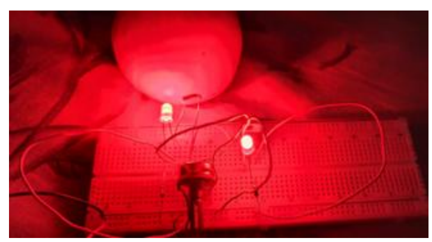

Figure 3: Output

- Unripe green fruits did not reflect enough light to reach the gate threshold.
- Ambient light changes were managed with a fixed LED light source.
- Calibrating the potentiometer allowed adjustments for different fruit types and settings.

B. Limitations

- The system does not work well for fruits that don't change color when ripe, like green grapes.

- It is sensitive to environmental lighting without a controlled source.
- Classification is limited to only ripe or unripe, not the stages in between.

C. Improvements

Despite limitations, the circuit works reliably within its design limits and provides a practical way to classify fruit ripeness.

IX. Major Contributions

- Developed a low-cost, light-based ripeness detection system using analog parts.
- Tested and confirmed the circuit through both simulation and physical testing.
- Showed real-time ripeness feedback with minimal user input. • Helped reduce food waste and support sustainable farming.
- Created a prototype suitable for scaling in educational, market, or field settings.

X. Future Work

The system can be improved in several ways:

- **Microcontroller Integration:** Use Arduino to digitize and log sensor data and add an LCD for real-time display.
- **Wireless Capability:** Include Bluetooth or Wi-Fi for smartphone connectivity.
- **RGB or Spectral Sensors:** Expand the detection range for more types of fruit.
- **Battery-powered Portable Unit:** Encase the circuit in a sturdy enclosure for field use.
- **Gas and Texture Sensing:** Add ethylene gas sensors or tactile sensors for more comprehensive ripeness detection.
- **AI-based Analysis:** Implement image processing or machine learning with integrated camera modules for stage-based ripeness classification.

XI. Conclusion

This project effectively shows a simple and low-cost method for detecting fruit ripeness using visible light and a basic analog circuit. The switching mechanism based on the IRFZ44N MOSFET, controlled by light reflectance measured by an LDR, provides reliable and instant feedback. The system is adaptable, energy-efficient, and accessible to users in low-resource settings. With further enhancements, it can become a strong, multipurpose agricultural tool that boosts efficiency, reduces waste, and supports informed harvesting decisions.

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