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# AUTOMATIC LOAD SHARING TRANSFORMER

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**ABSTRACT-**
A crucial component of contemporary power systems is electrical load control, particularly when several electrical loads are coupled to a single transformer.Overloading a transformer above its r ated capacity can cause a number of dangerous problems, including voltage drops, higher power losses, and transformer overheating. windings, insulation failure, and ultimately a reduction in transformer lifespan. Continuous overloading may also lead to unexpected power outages and increased maintenance costs, making effective load management essential for reliable power distribution.To address these challenges, load sharing using multiple transformers is widely adopted in power distribution systems. Load sharing ensures that electrical demand is distributed evenly among available transformers, thereby preventing overloading of any single unit and improving overall system efficiency and reliability.

## I. INTRODUCTION

The design and execution of an Arduino UNObased Load Balance Sharing Transformer System, in which the electrical load is automatically monitored and divided between two transformers bas ed on current demand in real time, is presented in this work.A current sensing module (voltageba sed ACS712 sensor) is used by the system to continually detect the load current.The Arduino UN O intelligently controls the transformer based on the detected current value. operation through relay modules. A 16×2 LCD display is incorporated into the system to provide real-time visual feedback, displaying both the measured load current and the operational status of the transformers. This allows users to easily monitor system behavior and understand how load sharing occurs under different load conditions.In this prototype implementation, four incandescent bulbs are used as electrical loads to simulate real-world power consumption. Under normal operating conditions, when only Bulb 1 and Bulb 2 are switched ON, the load current remains within a predefined safe limit, and power is supplied solely by Transformer-1. As additional loads (Bulb 3 and Bulb 4) are turned ON, the total current drawn by the system increases. When this current exceeds a preset threshold value, the Arduino UNO automatically activates Transformer-2 through a relay, thereby sharing the load between the two transformers.

## II. OBJECTIVES

- To design a load sharing system using Arduino UNO
- To monitor load current using a current sensor (ACS712T 20A)
- To automatically switch an additional transformer when load increases
- To display real-time current and transformer status on a 16x2 LCD
- To prevent overloading of a single transformer

## III. SYSTEM OVERVIEW

The ACS712 current sensor, which is interfaced with the Arduino UNO, is used to measure the load current in order to continuously monitor the electrical load.The analog output voltage produ ced by the ACS712 sensor is proportionate to the current passing through the attached load.Thro ugh its analog input pin, the Arduino continuously samples this voltage signal and processes it in real time.The Arduino uses preset calibration settings, such as the sensor sensitivity and zerocurr ent offset, to translate the detected analog voltage into a comparable current value.The maximum safe operating current for a single transformer in the system is represented by a predetermined th reshold current level, which is then compared with this processed current value.When the measured load current remains below the threshold value, it indicates that the connected load can be safely handled by a single transformer. Under this condition, the Arduino maintains the relay in its inactive state, ensuring that only Transformer-1 remains operational and supplies power to the load. This mode of operation reduces unnecessary switching and improves system efficiency.

As the electrical load increases and the measured current exceeds the threshold value, the Arduino detects the overload condition in real time. In response, the Arduino activates the relay module by changing the logic state of the corresponding digital output pin. This action switches Transformer-2 ON and connects it to the load, thereby enabling load sharing between Transformer-1 and Transformer-2. This prevents overloading of the primary transformer and ensures stable and reliable power delivery.

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Throughout the entire operation, the Arduino acts as the central control unit by continuously processing sensor data, executing decision-making logic, controlling the relay for transformer switching, and updating the 16×2 LCD display. The LCD provides real-time information such as the current load value and the operational status of both transformers, allowing users to easily monitor system behavior and verify proper load-sharing operation.

## IV. HARDWARE COMPONENTS

- Arduino UNO

The Arduino UNO is a popular microcontroller development board based on the ATmega328P microcontroller. It acts as the main control unit of the system, responsible for reading sensor data, processing logic, and controlling output devices. The board operates at 5 V and provides multiple digital and analog input/output pins, making it easy to interface with sensors, relays, and display modules. In this project, the Arduino UNO reads current values from the ACS712 sensor, controls the relay for transformer switching, and updates the 16×2 LCD display, enabling automatic load balancing and real-time monitoring.

- ACS712T 20A Current Sensor

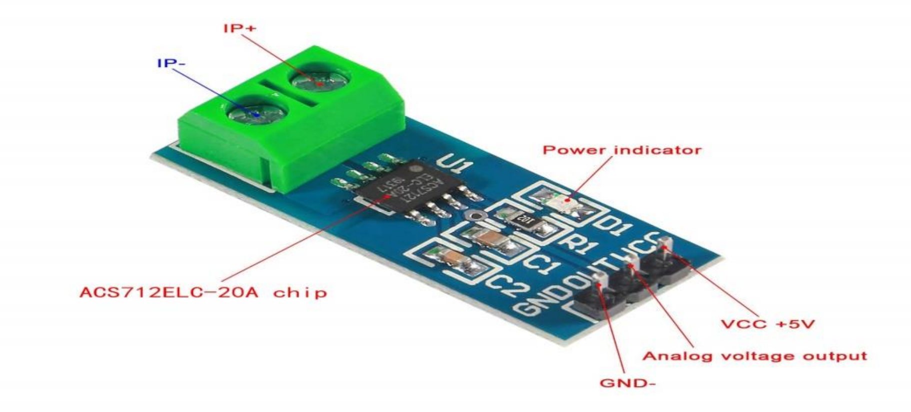


Fig.1 - ACS712T 20A Current Sensor

The ACS712T 20A current sensor is a Hall-effect based linear current sensing device used to measure both AC and DC currents. It provides an analog voltage output that is directly proportional to the current flowing through its conduction path. Due to its accuracy, electrical isolation, and ease of interfacing, the ACS712 sensor is widely used in embedded systems and power monitoring applications.

In this project, the ACS712T 20A sensor is used to continuously monitor the total load current drawn by the connected electrical loads (bulbs). The sensor operates by detecting the magnetic field generated by the current flowing through an internal copper conductor. This magnetic field is converted into a proportional voltage using the Hall-effect principle. The output voltage varies linearly with the current and is centered around a fixed reference voltage when no current is present.

The ACS712T 20A variant has a sensitivity of approximately 100 mV per ampere, making it suitable for medium-current measurement applications. When no current flows through the sensor, the output voltage remains at approximately 2.5 V, known as the zero-current offset. Any increase or decrease in load current causes a corresponding rise or fall in the output voltage, which is detected by the Arduino UNO through its analog input pin.

The analog output of the ACS712 sensor is connected to the A0 pin of the Arduino UNO, where it is sampled using the internal Analog-to-Digital Converter (ADC). The Arduino processes this voltage by applying calibration values such as sensitivity and zero-point offset to calculate the actual load current in amperes or milliamperes. To improve measurement accuracy, multiple readings are taken and averaged, reducing the effect of noise and fluctuations.

- Two Transformers (represented using relay-controlled supply)

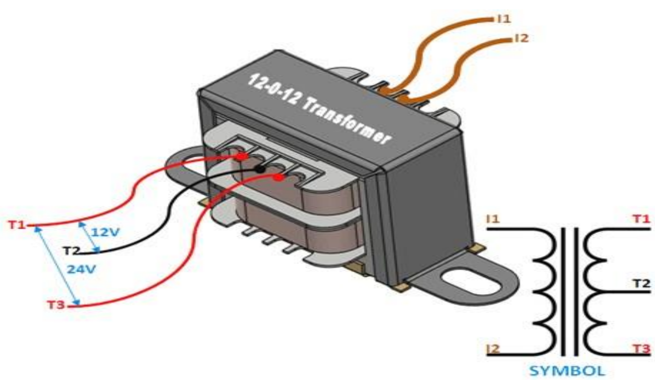


Fig. 2 - Transformers

Transformers are electrical devices used to transfer electrical energy between circuits through electromagnetic induction while maintaining electrical isolation. In this project, two transformers are used to demonstrate load sharing and load balancing operation. Each transformer is responsible for supplying power to a portion of the total electrical load. Initially, Transformer-1 supplies power when the load demand is low. As the load increases beyond a predefined threshold, Transformer-2 is automatically activated through a relay controlled by the Arduino

UNO. This arrangement prevents overloading of a single transformer, improves system reliability, and ensures efficient power distribution.

- Four Bulbs (Load)
- Relay Module
- 16x2 LCD with I2C Module


Fig. 3 - LCD

The 16×2 Liquid Crystal Display (LCD) with an I2C interface module is used to display real-time system information in a clear and user-friendly manner. The display is capable of showing 16 characters per line across two lines, making it suitable for presenting measured current values and transformer operating status simultaneously.The I2C module significantly reduces the number of connections required between the LCD and the Arduino UNO. Instead of using multiple data and control lines, the I2C interface uses only two communication lines, namely SDA (Serial Data Line) and SCL (Serial Clock Line), along with power and ground connections. This simplifies circuit wiring, improves reliability, and saves Arduino input/output pins.

- Breadboard
- Connecting Wires
- 9V Power Supply

The 9V power supply provides the necessary electrical power to operate the Arduino UNO and the associated low-voltage components of the system. It serves as the primary input power source for the control circuitry, ensuring stable and reliable operation of the microcontroller, sensors, relay module, and display unit.

In this project, the 9V supply is connected to the VIN pin or DC barrel jack of the Arduino UNO. The onboard voltage regulator of the Arduino converts the 9V input into a regulated

## V. WORKING PRINCIPLE

1. Analog Current Sensing and Data Acquisition

The Arduino UNO continuously reads analog voltage values from the ACS712 current sensor through its analog input pin A0. The ACS712 sensor produces an output voltage that is directly proportional to the amount of current flowing through the connected load. To obtain accurate readings and reduce noise, multiple analog samples are taken in a loop and averaged before further processing.

2. Current Calculation Using Calibration Parameters

The sampled analog values are converted into voltage using the Arduino's built-in 10-bit Analog-to-Digital Converter (ADC). This voltage is then converted into actual load current by applying the sensor's sensitivity factor and zero-point calibration value. The zero-point represents the sensor output voltage when no current is flowing, while the sensitivity defines how much the output voltage changes per ampere of current. This calibration ensures accurate and stable current measurement.

3. Normal Load Condition (Transformer-1 Operation)

When only Bulb 1 and Bulb 2 are switched ON, the total load current remains relatively low and within the safe operating range of Transformer-1. Under this condition, the Arduino keeps the relay in the OFF state, ensuring that only Transformer-1 supplies power to the connected loads. This helps in minimizing unnecessary operation of the second transformer and improves overall system efficiency.

4. Increased Load Condition Detection

As Bulb 3 and Bulb 4 are switched ON, the total current drawn by the load increases significantly. The Arduino continuously compares the measured current value with a predefined threshold level of 600 mA, which represents the maximum allowable load for a single transformer in this prototype.

5. Automatic Transformer Switching and Load Sharing

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When the measured current exceeds the 600 mA threshold, the Arduino automatically activates the relay module by changing the logic level at the relay control pin. This action switches Transformer-2 ON and connects it to the load. As a result, the electrical load is shared between Transformer-1 and Transformer-2, preventing overloading of Transformer-1 and ensuring stable system operation.

6. Real-Time Monitoring and LCD Display

Simultaneously, the Arduino updates the 16×2 LCD display with real-time system information. The first line of the LCD shows the measured load current in milliamperes (mA), while the second line displays the operational status of the transformers, such as “TX-1 ON TX-2 OFF” or “TX-1 ON TX-2 ON”. This provides clear and continuous visual feedback to the user regarding system performance and load-sharing conditions.

7. Software Description

The program is written in Embedded C using Arduino IDE. Major tasks performed by the code:

- Reading analog sensor values
- Calculating voltage and current
- Applying threshold logic
- Controlling relay and LED
- Displaying values on LCD
- Arduino IDE
- Embedded C / Arduino programming language

The Arduino IDE is used to write, compile, and upload the control program to the Arduino UNO.

Introduction to Arduino IDE

The Arduino Integrated Development Environment (IDE) is an open-source software used for writing, compiling, and uploading programs (sketches) to Arduino microcontroller boards such as Arduino UNO, Mega, Nano, etc. The IDE provides a user-friendly platform that simplifies embedded system development by combining a code editor, compiler, and uploader into a single application.

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## VI. RESULT

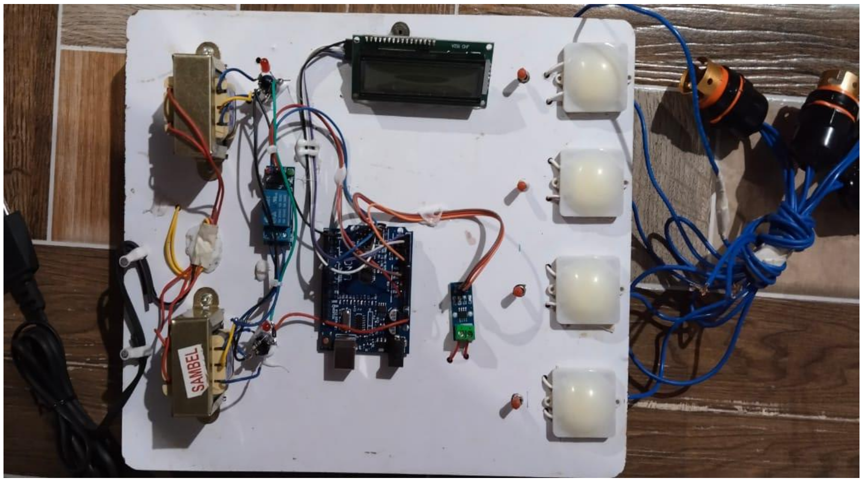



image shows the final working hardware model of a Load Balance Sharing Transformer System using Arduino UNO, designed to automatically share electrical load between two transformers and prevent overloading. The entire system is mounted neatly on a single base board, demonstrating a practical and real-time implementation suitable for academic and industrial learning purposes.

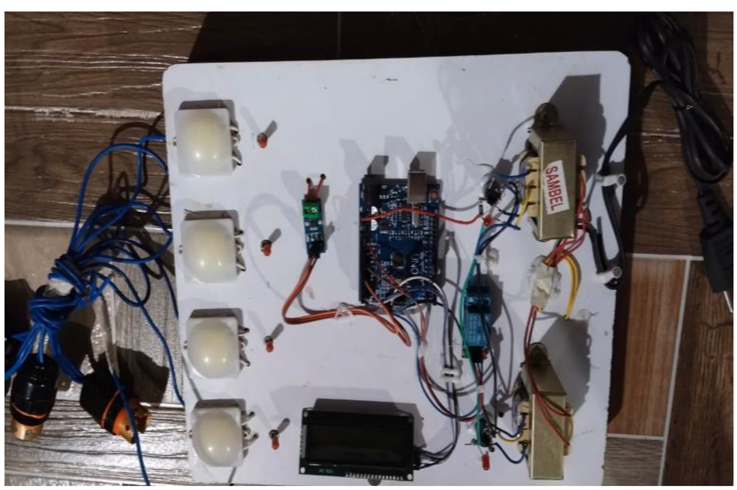
At the center of the system is the Arduino UNO, which acts as the main control unit. The Arduino continuously receives current data from the connected current sensor and processes it using a predefined program. Based on this data, it decides whether the load condition is safe or overloaded. All control decisions such as switching transformers and updating display information are handled by the Arduino, making it the brain of the system.

The ACS712 current sensor is connected in series with the load. This sensor measures the current drawn by the connected electrical loads and sends an analog signal to the Arduino. The sensor plays a crucial role in detecting overload conditions. Whenever the load current exceeds a predefined threshold, the sensor output changes accordingly, allowing the Arduino to take corrective action.

Two step-down transformers are placed at the bottom of the setup. These transformers represent two independent power sources used for load sharing. Under normal operating conditions, one transformer supplies power to the load. When the primary transformer becomes overloaded, the system automatically transfers part or all of the load to the secondary transformer using relay-based switching. This ensures uninterrupted power supply and protects the transformers from thermal damage.

The relay modules act as electrically controlled switches between the transformers and the load. These relays are controlled directly by the Arduino through digital output pins. When the Arduino detects an overload, it energizes the relay coil, which changes the connection from one transformer to the other. The relay-based isolation ensures safe and reliable switching without manual intervention.

Four incandescent bulbs are used as electrical loads in the system. These bulbs help visually demonstrate load variation and transformer switching. As the load increases, the system dynamically responds by redistributing the load. The glowing bulbs make it easy to understand and observe the system behavior during demonstrations and evaluations.




Overall, the final working model successfully demonstrates an automatic load balancing and transformer protection system. It improves efficiency, reduces manual intervention, increases transformer lifespan, and enhances power system reliability. This project has strong applications in industrial power systems, substations, smart grids, and educational laboratories, making it a practical and scalable solution for modern electrical engineering challenges.

## VII. CONCLUSION

Effective automatic load distribution between two transformers based on realtime current demand is demonstrated by the Arduino UNO-based Load Balance Sharing Transformer System. Uneven load distribution in contemporary power systems can result in energy losses, transformer overloading, and shortened equipment lifespans.By automatically switching transformers to maintain balanced operation and continuously monitoring the load current of linked devices, this system overcomes these difficulties.Using current sensors and an Arduino UNO microcontroller, the system detects when the load on one transformer exceeds a predefined threshold and automatically activates the other transformer to share the load. The 16×2 LCD provides real-time information on load currents, transformer status, and switching operations, offering both visual feedback and monitoring capabilities.

This paper not only ensures efficient utilization of transformer capacity but also reduces the risk of power outages and equipment damage due to overloading. By implementing automatic load sharing, the system contributes to energy conservation, operational reliability, and enhanced safety.