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Electricity Leakage Detection and Overvoltage Protection in Residential Buildings

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ABSTRACT: In many residential structures, the electrical wires for separate homes are put in the same conduit pipe. When this happens, it is possible to make mistakes when identifying similar-colored wires. Most of the faults are caused by the neutral interconnection in the wiring system. Usually neutral wires are connected to neutral bus within the panel board or switchboard, and are "bonded" to earth ground. Our secondary distribution generally uses the tree structure of supply. Even under conditions of an imbalanced load, the voltage of each phase to neutral will be kept at its rated value. Poor neutral wire connections cause the voltage at each phase to differ from one another; this isolated neutral point, known as a floating neutral, has a fluctuating voltage. This is the cause of damaged appliances caused by over voltage that should be protected. In this study, a smart system that detects power leakage and protects the residential structure from overvoltage is suggested.

KEYWORDS: Low power devices, faults, neutral leakage, voltage protection, loads, and operational amplifiers

I. INTRODUCTION

Consistency and protection are the two primary roles of electric circuit protection devices. By disconnecting the power supply from circuits, the over current protection method eliminates the risk of fire and electrocution and ensures that protection is provided. For some items, adherence to organizational principles and accurate protection may be necessary in addition. Circuits are protected from excessive voltages or currents by protection devices. Several voltage levels are used to transmit the electrical power produced at the generating plant to customers. Every installation or facility's electrical wiring is a calculation-based process that differs based on the needs and expectations. Circuit breakers are a necessary component of every effective electrical system. Ring provides power to the consumer units' main sockets. Radial lighting circuits are a crucial component of the wiring system [1].

Heavy duty electrical wiring that is used for high power equipment like HVAC, cookers, heavy duty geysers, etc. has dedicated circuit breakers. Over voltage protection is combated using the following techniques (i) Earthing screen, overhead ground wires, lightning arresters, and surge diverters are the other options. Current sensors, voltage sensors, and actuators are used as over voltage protections in residential buildings.

Electric circuit protection devices are used to avoid excessive current flow or short circuits [2]. Fuse, Circuit Breaker, Poly Switch, RCCB, Metal Oxide Varistor, Inrush Current Limiter, Gas Discharge Tube, Spark Gap, Lightning Arrester, etc. are just a few examples of the various devices that are used to protect circuits.

Every electrical installation needs to be properly grounded. The goal of earthing is to guarantee that there is a path for fault current to flow after a fault has occurred that will trip the main circuit. Accidents, both fatal and not, are prevented because grounding prevents the floating voltage state. A working earthing system is necessary for every household or industrial wiring system. Typically, consumer units include an isolator, tiny circuit breakers, grounding terminals, and a circuit path [3]. Moreover, MCBs and fuses isolate the issue from the circuit. Fuses and a few MCBs are less susceptible to severe transient failures, making them the preferred choice for lighting circuits.

The mainstays of household electrical protection are fuses and MCBs [4]. The inability of MCBs to detect residual current (earth leakage current). Residential Current Circuit Breaker (RCCB) is designed to limit the risk of electric

shock injuries and is impervious to overloads and short circuits in order to solve this issue. RCCB-protected circuits must always have separate overload and short circuit protection. Leakage current is the term for the flow of current to the earth. Leakage current could flow from any conductive element or the surface of a non-conductive part to ground if there is no connection to the ground. A grounding system is typically added to protect against a shock danger in the event of an insulation failure.

A grounding conductor links the equipment to the earth as part of the grounding system. The voltage is switched to ground if the insulation between the power line and conductive components fails. In order to avoid a shock hazard, the ensuing current flow blows the fuse or trips a relay and opens a circuit breaker. That implies that there could be a shock risk if the ground connection is broken [6]. If the leakage current running through the ground conductor is interrupted, even in the absence of insulation failure, it could result in a shock hazard for anyone touching both the ground and the ungrounded equipment at the same time. The primary causes of electrical failure are switching surges, insulation failure, arcing ground, resonance, and lightning.

Use of two distinct layers of insulation can still provide protection even if the device is not grounded. The terms "ac leakage" and "dc leakage" refer to two distinct categories of leakage currents. DC leakage current is typically caused by the final product's machinery rather than the power sources. Between a voltage source (an ac line) and the ground, there is AC leakage current due to the parallel combination of capacitance and dc resistance [7].

II. PROPOSED SYSTEM

This technology can identify the neutral wire connections between each given consumer's circuits. The alarm is activated once the defect has been located. In order to prevent damage to appliances, it also recognizes significant voltage swings and cuts off the EB mains supply. For Connectivity fault & high voltage scenarios, both warning & circuit breaking are possible. The two major components of this system are a voltage sensing device and a current detecting device.

The LM324IC on the control circuit's board is responsible for detecting signals from voltage and current measuring devices. Effective fault detection and power shut-off are crucial for reducing faults brought on by electrical leakage. The protection devices restrict the amount of service interruption by detecting problems and activating circuit breakers and other devices.

2.1 System Design

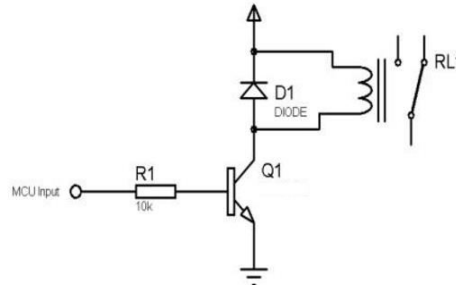
The proposed system's block diagram is depicted in Figure 1. It primarily consists of two energy metres, designated as energy metres consumers "A" and "B," which get their input power supply from the EB mains.

The energy metre "A" is connected to a contactor and a load. Current transformers and potential transformers are connected between the energy metre and the contactor for current and voltage sensing, respectively. The load "B" is connected to the energy meter's output. Between loads "A" and "B," a neutral interconnection switch is attached.

The output signal of the current transformer is fed to the OP-AMP section and driver unit, and it keeps track of neutral leakage current. Both energy metres can read the power flow while the neutral interconnection switch is left open, which is usual. The neutral current running via the neutral wires collapses when the neutral interconnection switch is closed, and both energy metres become unstable. The power leakage warning sounds if the consumer "A" has the minimal load or no load consumed but the energy metre displays a fault reading, meaning a greater reading than the actual consumption. To prevent annoying tripping, the contactor's activation can be customized [8]. The comparator and driving unit receive the potential signal from the transformer for overvoltage protection. The relay driver interrupts the contactor and activates the overvoltage warning during the high voltage state to prevent harm to the devices [9].

2.2 Relay Driver Circuit

A relay is driven, or operated, by a relay driver so that it can perform as intended. Figure 3 demonstrates the particulars. Relay Driver Circuit in Figure 2.



Depending on the needs of the circuit, the relay can act as a switch in the circuit to open or close a circuit path. Relays employ electromagnets to move a pair of movable contacts from the open to the closed state. Relays have long been a common device. Relays have specific characteristics that make them more resilient than solid-state devices, despite the fact that solid state switches increasingly replace relays. High current capacity, ESD resistance, and drive circuit isolation are some of these special qualities.

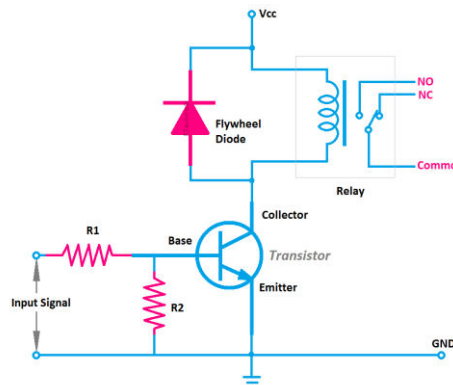


Fig: Relay Switch Circuit Diagram

Relays have the benefit of being able to control motors, heaters, lamps, or AC circuits even if the relay coil can be operated with very little power. The neutral connection collapses and both energy meters’ readings become irregular when the interconnection switch is closed. Energy metre "B," which is consuming some load, reflects its reading to energy metre "A," which is the consumer when there is no load. The neutral inter electrical power is to blame for the error in the energy metre measurement. Relays exist in a wide variety of forms, dimensions, and styles and are used in numerous electronic circuits.

2.3 Circuit Operation

Figure 4's circuit layout features two energy metres, consumers "A" and "B," whose input terminals receive voltage from the EB main supply.

Consumer "A" meter's output terminal is connected to a contactor and the output of the contactor is connected to the distribution board as an input supply. Consumer "B" meter's output terminal is directly connected to the distribution board. For demonstration purposes, a switch for connecting between consumers "A & B" is available. When everything is in order, the Neutral Interconnection Switch is left open, and both energy metres are reading normal power [11].

The neutral connection collapses and both energy meters’ readings become irregular when the interconnection switch is closed. Energy metre "B," which is consuming some load, reflects its reading to energy metre "A," which is the consumer when there is no load. The neutral interconnection is the cause of the error in the energy metre reading. The power loss is detected by CT in this situation, and the sensed signal is amplified in the op-amp section, which in turn drives the driver unit to switch on the relay and buzzer unit.

If necessary, the relay unit regulates the contactor coil to open or close the main circuit. Customers are alerted by buzzer audio and are able to locate the fault in their electrical circuit. They can then determine precisely where the fault occurred by toggling each MCB in the DB one at a time until the buzzer noise ceases.

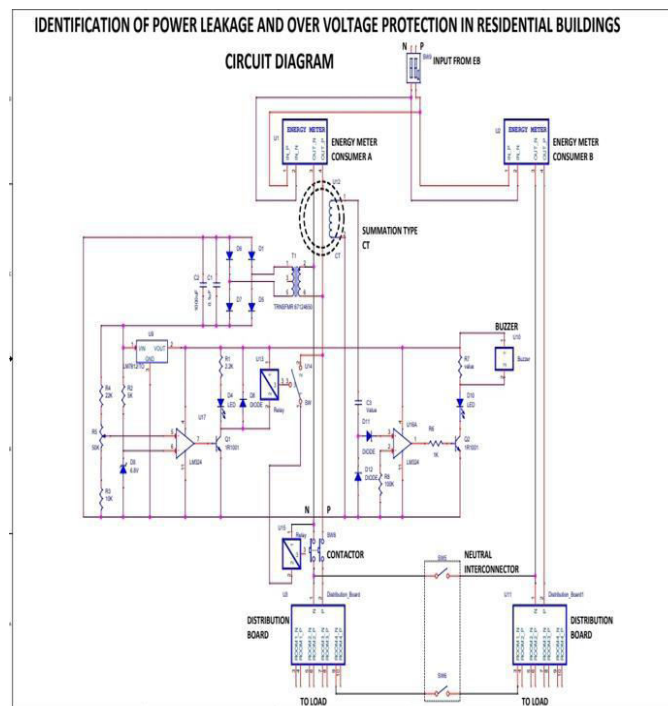


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So, a qualified individual should address the wiring system failure as soon as possible. A potential transformer is connected in the circuit, and the primary side receives 230V ac voltage, which is the output from the energy metre, as raw power. Step-down windings on the secondary side of the transformer supply the rectifier section, which consists of four diodes bridged together, with a voltage of 18 volts.

Here, the AC voltage is changed to DC, and the impure DC is then filtered by a 1000 mfd capacitor to provide pure DC voltage. The high voltage protection circuit and regulator 7812 receive the voltage. The complete circuit, including the power supply for the LM324 IC and relay driver units, is powered by the output of the 7812. Via resistors R2, R3, R4, and R5, the LM324 IC's fifth and sixth pins receive the bridge rectifier output voltage, resulting in pin 6 being set to 6.8V with Zener diode D9 attached. The voltage is compared using the op-amp as a comparator, and the output is high or low depending on the input voltage.



In resistor R5, the voltage parameter is adjustable. When the input voltage reaches 260 V, or when there is a high voltage condition, the comparator's output pin 7 drives the transistor Q1 to switch on the relay unit and buzzer. The contactor SW8 is controlled by the relay to cut off the main supply and safeguard home appliances. The contactor SW8 turns ON/OFF according to the fault that occurred for both neutral leakage and over voltage faults and individual alarm notification through buzzer and led indication is carried out. Red led indication with time delay buzzer sound is enabled for neutral connector faults, and red led indication with continuous beep sound is enabled for excess voltage faults.

III. RESULTS AND DISCUSSION

Figure 5 and Figure 6 depict the control circuit board and hardware implementation of the proposed circuit, respectively. The following discussion covers the outcomes.

3.1 Method of Power Leakage Identification (Balanced Load)

The hardware implementation of the proposed circuit is shown in Figure 5 and the control circuit board in Figure 6. The result obtained is discussed below.

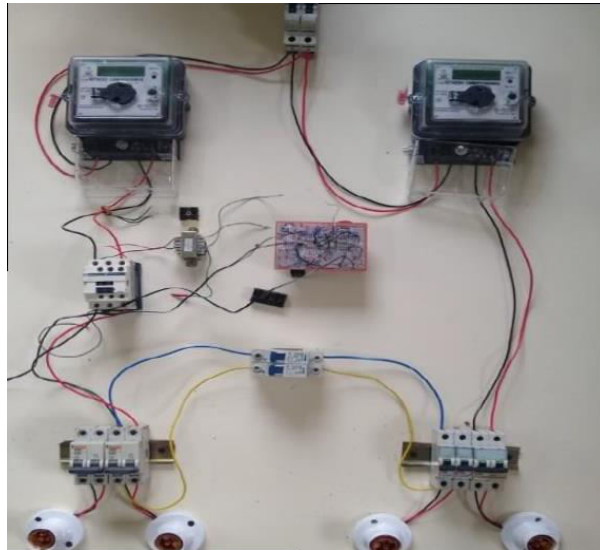


Figure 5: Circuit Implementation

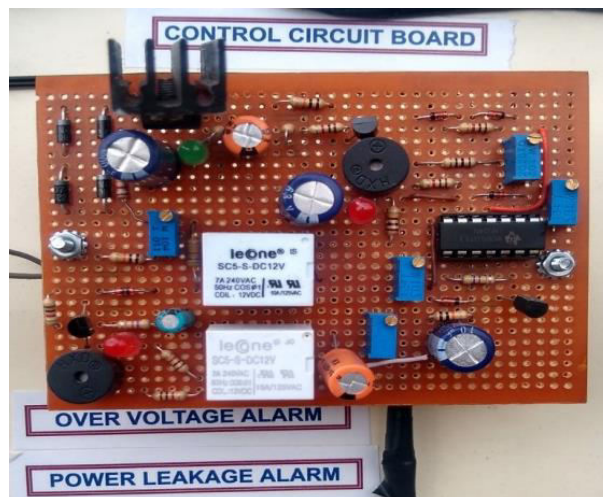


Figure 6: Control Circuit Board

Table 1: Neutral Interconnection Switch “Off” (Balanced Load)

Consumer	Connected Load (W)	Load Current (A)
A	100	0.46
B	100	0.46

The load current for the balanced approach of identifying power leaks is shown in Table 1 with the neutral connector switch turned off. Consumers "A" and "B" are connected to a 100W load, as illustrated in Table 1. As there is no interconnection in the circuit and the load current is 0.46A, the system is stable.

Table 2: Neutral Interconnection Switch “On” (Balanced Load)

Consumer	Connected Load (W)	Load Current (A)
A	100	0.30
B	100	0.56



In the following scenario, this is depicted in Table 2, consumers “A” and “B” are connected to a 100W load with the neutral interconnection switch “on.” The interconnection switch is turned "ON," consumer A's load current is 0.43A, and consumer B's load current is 0.56A. Due to neutral connectivity, customer 'A' metres read less current and consumer 'B' metres read higher current. As a result, this system is unstable.

3.2 Method of Power Leakage Identification Unbalanced Load

The connected load and load current are provided in Table 3 for the method of power leakage identification (balanced) with neutral interconnection switch "off. Consumer 'A' is not linked to a load, as shown in Table 3, but Consumer 'B' is connected to a 100W load. When the interconnection switch is set to "OFF," consumer A's load current is 0.0 A and consumer B's load current is 0.46 A. As long as the consumer "B" metre reports normal load current, the system remains stable.

Table 3: Neutral Interconnection Switch “Off” (Unbalanced Load)

Consumer	Connected Load (W)	Load Current (A)
A	0	0.0
B	100	0.46

Table 4: Neutral Interconnection Switch “On” (Unbalanced Load)

Consumer	Connected Load (W)	Load Current (A)
A	0	0.24
B	100	0.22

Table 4 displays the readings when the neutral switch is turned on. Consumer 'A' connected with no load, while Consumer 'B' connected with a 100W load, as stated in Table 4. Consumer 'A's' load current is 0.24A when there is no load connected, while Consumer 'B's' metre reads 0.22A when there is a connected load of 100W when the interconnection switch is turned on. The system is unstable and the metres read irregularly.

3.3 Methods for Over Voltage Protection

Table 5: Over Voltage Testing

Input Voltage	Contactor	Buzzer/Led
220V	ON	OFF
230V	ON	OFF
240V	ON	OFF
260V	OFF	ON

As seen in Table 5, an auto transformer that progressively increases from 220V to 260V is used to change the supply voltage. Over voltage buzzer and LED are turned on above 255V. The contactor turns on the supply to the distribution board for consumer "A." The consumer is safeguarded against overvoltage.

When compared to current approaches, this proposed method has the following advantages.

- i. Faster response times,
- ii. economic viability,
- iii. operational simplicity,
- iv. high system reliability,
- v. Safety and Security are only a few of the benefits.

IV. CONCLUSION

With the use of this equipment, regular people may quickly determine whether their home is electricity leakage-free. If there is any power leakage, the gadget notifies the user visually and loudly and isolates the leakage. It makes the



consumer aware that the error can be fixed with a technical person's assistance. The tool also makes it simple for the technical expert to locate the fault. It aids consumers in keeping each home's electrical system in good condition. Customers can save money and pay actual energy consumption costs. With the aid of our equipment and the digital energy metres, the consumer will be delighted with precise and accurate energy measurement. The customer is aware that the bill is appropriate given their consumption. Thus, the aforementioned device is used to resolve billing-related issues between the customer and the supplier.

Using our gadget automatically lowers billing-related complaints to an acceptable level. As a result, the supply provider can use the opportunity to better address the issues of other customers. It prevents financial loss caused by unnecessary metre changes brought on by inaccurate observations. The money saved is put towards a variety of other beneficial Supply Company development initiatives. Here, the consumer and the supplier can establish a solid working connection. While it is a tiny item, it aids in the resolution of larger issues.

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