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Locating Power Leaks and Preventing Power Outages in Residential Structures

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ABSTRACT: The electrical cables from each home are often strung in the same conduit pipe in apartment complexes, which may lead to confusion when trying to distinguish between wires of different colours. A majority of wiring problems originate at the neutral connector. Typically, neutral wires are "bonded" to earth ground and attached to the neutral bus on the panel board or switchboard. We mostly use the tree structure of supply in our secondary distribution. Even when the load is imbalanced, the voltage from each phase to neutral will remain at its rated value. The voltage at each phase will be different if the neutral wire connection is weak; this isolated neutral point is known as a floating neutral, and its voltage is constantly changing. Overvoltage may harm appliances that are supposed to be protected from it, and here is why. This research proposes a smart system that can detect power leakage and safeguard a residential structure from overvoltage.

Keywords: Neutral Leakage, faults, low power devices, Voltage Protection, Load, Operational Amplifier

1. INTRODUCTION

Consistency and protection are the two primary roles of electric circuit protection devices. In order to eliminate the risk of fire and electrocution, an over current protection mechanism cuts power to circuits. Precise packaging may be necessary for some items in order to adhere to company regulations. To prevent circuits from being damaged by excessive voltages or currents, protection devices are installed. The voltage levels at which electrical power is transmitted to customers vary depending on the producing facility. Electrical wiring is a calculation-oriented procedure that differs from one installation or facility to another based on needs and expectations. Including circuit breakers in every well-designed electrical system is essential. Consumer units' main sockets are supplied by ring type circuits. Lighting circuits, which are essentially radial in shape, are an integral aspect of any wiring system [1].

Electrical appliances with a lot of power consumption, such as air conditioners, stoves, geysers, etc., need special circuit breakers in their wiring. In order to prevent damage from voltage surges, people use I earthing screens, (ii) above ground cables, and (iii) surge diverters or lightning arresters. In order to prevent overvoltage in residential structures, current sensors, voltage sensors, and actuators are used.

The electric circuit protection device's main function is to safeguarding against an excess of current or a short circuit [2]. Fuse, Poly Switch, Relay, Current Limiter, Gas Discharge Tube, Lightning Arrester, Inrush Current Limiter, Metal Oxide Varistor, and many more devices are accessible for use in Protecting circuits.

A solid grounding connection is an essential component of any electrical system. Before a defect may cause the main circuit to trip, earthing ensures that fault current can flow in the event that a failure does occur. By preventing the floating voltage state, grounding helps to avert accidents, both deadly and non-fatal. A fully operational earthing system is an essential component of any residential or commercial electrical system. An isolator, small circuit breakers, grounding connections, and a circuit channel are the typical components of a consumer unit [3]. Other circuit breakers that may isolate a problem include fuses and MCBs. Typically, lighting circuits would employ fuses or certain MCBs since they are less susceptible to severe transient failures. When it comes to home electrical protection, fuses and MCBs are like the backbone [4]. Earth leakage current, or residual current, is undetectable by MCBs. A residential current circuit breaker (RCCB) is an ideal solution since it reduces the likelihood of electric shock injuries and is insensitive to overloads and short circuits. Dedicated overload and short circuit protection is an absolute need in RCCB-protected circuits.

"Leakage current" describes the flow of electricity that ends up on the ground. Without a ground connection, electricity might leak out of any conductive or non-conductive material and into the ground. Most electrical

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appliances come with a grounding mechanism that prevents electric shock in the event that the insulation fails [5].

The grounding system includes a grounding conductor that connects the equipment to the ground. If there is a failure of the insulation between the power line and conductive parts, the voltage is shunted to ground. The resulting current flow causes the fuse to be blown or trip a relay and open a circuit breaker; preventing a shock hazard. It means that a possible

shock hazard exists if the connection to the ground is interrupted [6]. Even if there is no insulation failure, if the leakage current flowing through the ground conductor is interrupted, it could pose a shock hazard to someone touching the ungrounded equipment and ground at the same time. Switching surges, Insulation failure, Arcing ground, Resonance and Lightning are the main reasons for the over voltage in the power system network.

If the equipment is non grounded, protection can still be ensured by using two separate layers of insulation. Two possible types of leakage currents are (*i*) ac leakage and (*ii*) dc leakage. DC leakage current usually due to the end-product equipment, and not the power supplies. The parallel combination of capacitance and dc resistance causes AC leakage current between a Voltage source (ac line) and the ground [7].

2. PROPOSED SYSTEM

The neutral wire connections between each consumer's circuits may be located using this approach. After the problem has been located, the alarm will go off. Additionally, it safeguards equipment from harm by cutting off the EB mains supply when it detects significant voltage fluctuations. When there is an interconnection problem or excessive voltage, either an alarm or a circuit break might go off. A voltage sensor and a current sensor are the key components of this system. An LM324IC, which receives signals from voltage and current sensors, is a component of the control circuit board. Effective fault detection and power shutoff are critical for reducing problems caused by electrical leakage. When problems are detected, the protection devices activate circuit breakers and other tools to reduce service loss.

2.1 System Design

Two energy meters, "A" and "B," which get their input power supply from the EB mains, are the main components of the proposed system, as depicted in Figure 1's block diagram. In order to sense current and voltage, a current transformer and a potential transformer are connected between the energy meter "A" and the load and contactor, respectively. Connected to load "B" is the output of the energy meter. In order to link loads "A" and "B," a neutral interconnection switch is used. The current transformer is responsible for monitoring the neutral leakage current and feeding the OP-AMP section and driver unit with the CT's output signal. Under typical circumstances, both energy meters will display the current flowing through the circuit, and the neutral interconnection switch will remain open. Both energy meters become unreliable when the neutral interconnection switch is closed, which collapses the neutral current flowing via the neutral wires. In the event that consumer "A" does not have any load or consumes the minimal load but the energy meter receives an incorrect reading—that is, a greater reading than the actual consumption—the power leakage alert will sound. To prevent annoying tripping, the contactor's activation may be adjusted [8].

The comparator and driving unit receive the potential signal from the transformer, which is used for overvoltage protection. While the

In the event of an overvoltage warning going off, the relay driver will cut power to the contactor, preventing any harm to the devices [9].

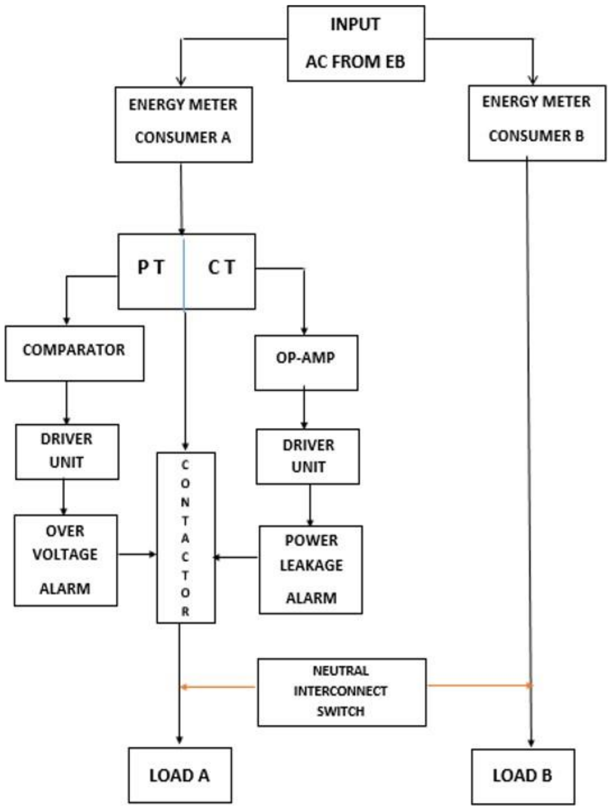

Figure 1: Block diagram of the proposed system

2.2 Relay Driver Circuit

The relay driver drives, or operates, a relay such that it can function in a desired manner. The details are shown in *Figure 3*.

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Figure 2: Relay Driver Circuit

The relay can operate as a switch in the circuit to open or close a circuit path, according to the needs of the circuit. To operate a pair of movable contacts from an open position to a closed position, relays use electromagnets. Relays have been in use

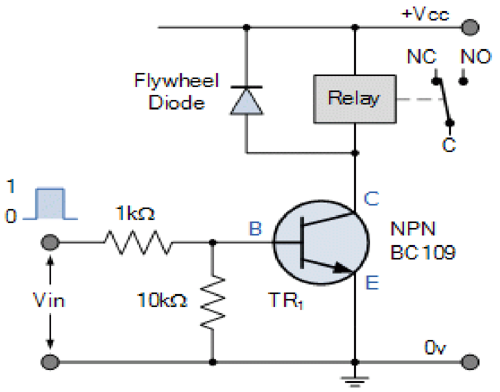

Figure 3: Relay Switching Circuit

The advantage of relays is that even though the relay coil can be operated with very low power, it can control motors, heaters, lamps or AC circuits which draw a lot more

for a long time. Though the solid state switches replace relay snow a day, relays have certain properties that make them more robust than solid-state devices. These unique properties are high current capacity, ability to withstand ESD and drive circuit isolation [10].

electrical power. The relay comes in a whole host of shapes, sizes and designs, and have many applications in electronic circuits.

2.3 Circuit Operation

The circuit diagram shown in *Figure 4* consist of two energy meters namely consumer “A” and consumer “B” where input terminals get input voltage from EB main supply.

The output terminal of consumer “A” meter is connected to contactor and contactor output is connected to distribution board as input supply. The output terminal of consumer “B” meter is connected directly to distribution board. An interconnection switch is provided between consumer “A & B” for demonstration purpose. In normal condition Neutral Interconnection switch is kept open and the power read out by both energy meters are normal [11].

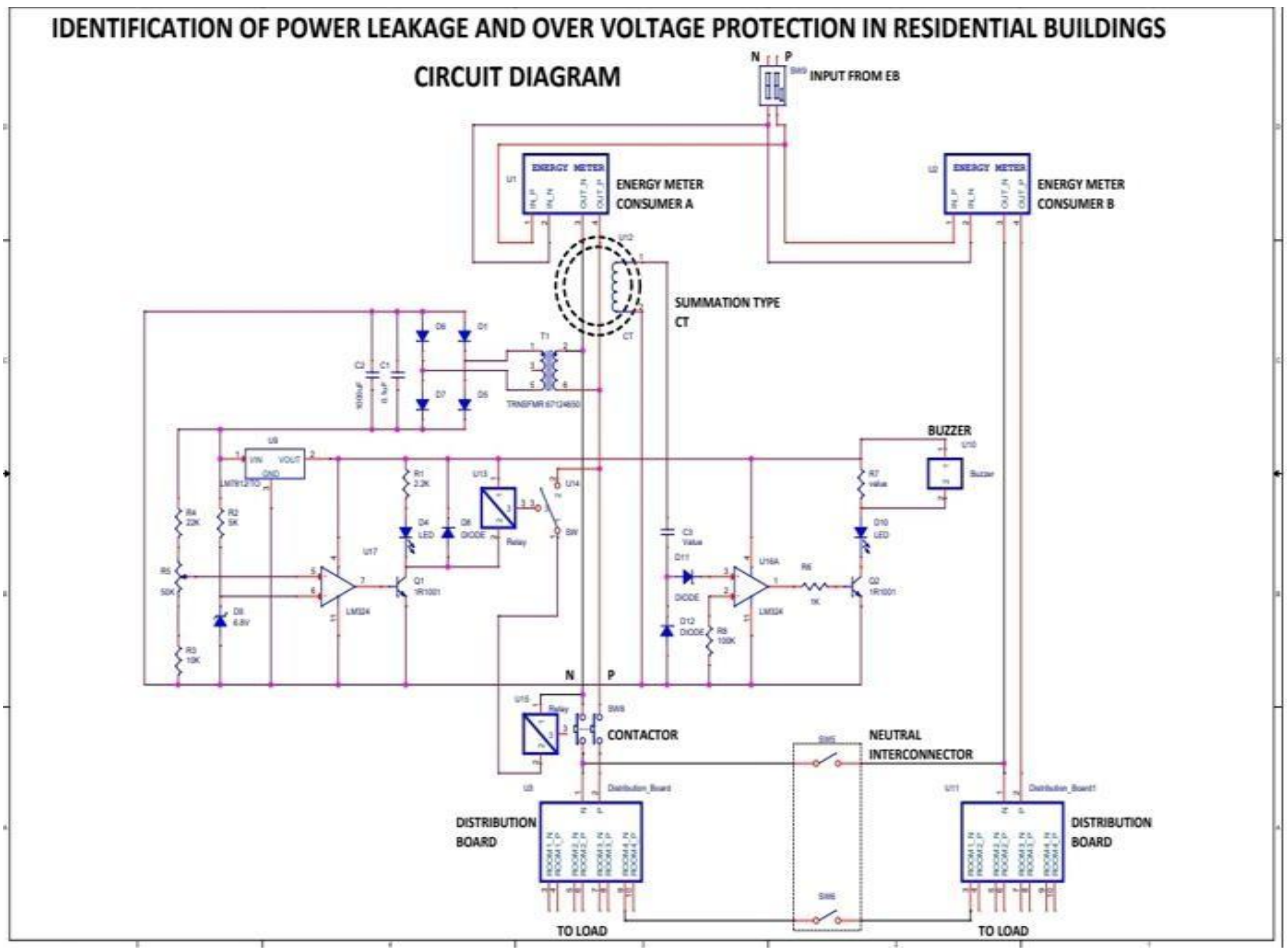

Figure 4: Detailed Circuit Diagram

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Both energy meters start to read irregularly when the interconnection switch is closed, which collapses the neutral connection. At a no-load scenario, the energy meters of consumer "A" mirror the readings of energy meter "B," which is drawing power. The energy meter reading error happened because to neutral inter connection. Here, the CT detects power loss, and the op-amp section amplifies the signal, which in turn triggers the driver unit to activate the buzzer and relay [12].

If the main circuit has to be opened or closed, the relay unit can do that by controlling the contactor coil. Customers may identify the problem with their electrical circuit and get a warning tone via a buzzer.

Then by individually turning off each MCB in the DB until the buzzer sound ceases, you may pinpoint precisely the room or connection where the issue occurred [13]. Then, a competent individual should fix the wiring system problem as soon as possible. A potential transformer is included into the circuit, with the main side receiving the raw power, namely 230V ac voltage, from the energy meter's output. The rectifier section, made up of four diodes linked in a bridge configuration, receives the voltage that has been reduced to 18 volts by the step-down winding on the transformer's secondary side [13]. The AC voltage is first converted to DC and then, to get pure DC voltage, the impure DC is filtered using a capacitor with a capacitance of 1000 mfd [14].

The high voltage protection circuit and regulator 7812 receive the voltage. The LM324 integrated circuit and the relay driver units are both powered by the 7812 output. With resistors R2, R3, R4, and R5, the output voltage of the bridge rectifier is sent to the fifth and sixth pins of the LM324 IC, respectively. Pin 6, which is linked to the Zener diode D9, is set to 6.8V. Here, the op-amp serves as a comparator, raising or lowering the output voltage in response to the input voltage.

Resistance R5 is where the voltage parameter is tweaked. The comparator's output pin 7 activates the transistor Q1 to activate the relay unit and buzzer under a high voltage situation, defined as an input voltage greater than 260 V. In order to prevent harm to household appliances, the relay activates the contactor SW8 and cuts power to the mains [15–17].

The contactor SW8 is set to activate or deactivate in response to neutral leakage or excess voltage problems, respectively, and each alarm is alerted individually with buzzer and light indicator [18]. For faults involving the neutral connection, a red light with a timed buzzer sound is activated, and for faults involving the excess voltage, a red light with a continuous beep sound is activated [19], [20].

3. RESULTS AND DISCUSSION

The hard ware implementation of the proposed circuit is shown in *Figure 5* and the control circuit board in *Figure 6*. The results obtained is discussed below.

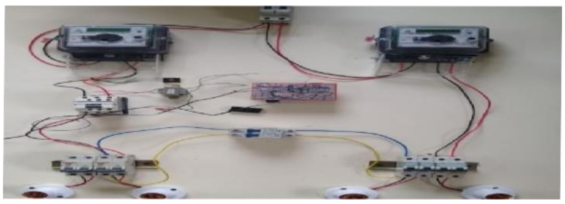

Figure 5: Circuit Implementation

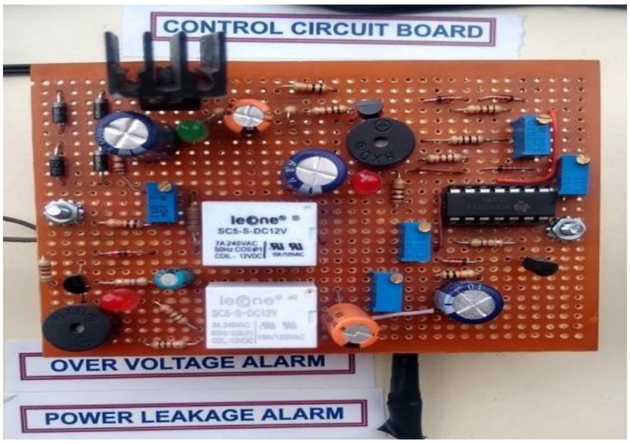

Figure 6: Control Circuit Board

3.1 Method of Power Leakage Identification (Balanced Load)

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

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

Table 1 shows the load current in the method of power leakage identification (balanced) with neutral interconnection switch “off”. As shown in *Table1* consumer ‘A’ and ‘B’ are connected to 100W load. Since the load current are 0.46A with no interconnection in the circuit, the system is in stable condition.

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

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

Consumer ‘A’ and ‘B’ are connected 100W load with neutral interconnection switch “on” in the next case

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which is shown in *Table 2*. The interconnection switch is 'ON' the load current of consumer 'A' is 0.43A and consumer 'B' is 0.56A. Consumer 'A' meter reads less current and consumer 'B' meter reads more current due to neutral interconnection. This system is therefore unstable.

3.2 Method of Power Leakage Identification Unbalanced Load

In the method of power leakage identification (balanced) with neutral interconnection switch "off, the connected load and load current are shown in *Table 3*. As in the *Table 3*, consumer 'A' is not connected to load and 'B' is connected to a load of 100W. With the interconnection switch is 'OFF', the load current of consumer 'A' is 0.0A and consumer 'B' is 0.46A. Consumer 'B' meter reads normal load current and hence this system is 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

The readings with the neutral switch "on" is shown in *Table 4*. As shown in *Table 4* consumer 'A' connected no load consumer 'B' connected 100W load. With the interconnection switch is 'ON', the load current of consumer 'A' is 0.24A without load and consumer 'B' meter reads a current of 0.22A with a connected load of 100W. Both the meters reads abnormally and the system is unstable.

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 shown in *Table 5*, the supply voltage is varied using an auto transformer which is gradually increased from 220V to 260V. Above 255V, over voltage buzzer and LED are activated. The contactor opens the supply to the consumer 'A' distribution board. The consumer is protected from the over voltage.

This proposed method has the following merits compare with existing methods

i. Better response time
ii. Economically viable
iii. Less complexity in operation
iv. Highly reliable system
v. Safe and secure system

4. CONCLUSION

The average person may use this equipment to quickly and simply determine whether their house is power leakage free. The gadget detects power loss and alerts the user both visually and aurally if there is a power loss. The customer is made aware of the need to seek assistance from a technical expert in order to fix the malfunction. Also, the gadget makes it easy for the engineer to pinpoint where the problem is. The customers are aided in keeping the electrical system in every residence in good working order.

Customers may save money by paying for their actual energy usage bills. Our technology, in conjunction with digital energy meters, will provide accurate and precise energy measurement, much to the delight of the customer. According to their use, the customer is aware that the cost is appropriate. Consequently, the aforementioned gadget resolves issues pertaining to invoicing that arise between the supplier and the customer.

Our gadget automatically reduces billing-related complaints to a minimum. As a result, the supply provider will have more time to address the concerns of other customers. It helps keep costs down since wasting money on meter changes caused by inaccurate observations is a real problem. Supply Company uses the money it saves for a variety of other beneficial development initiatives. Here is where the buyer and seller may establish a solid rapport. It may seem little, yet it helps address big issues.

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