Identification of Power Leakage and Protection of Over Voltage in Residential Buildings

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ABSTRACT: In many residential buildings the electrical wires of individual houses are laid in the same conduit pipe and some mistakes could be made in identifying similar coloured wires when they are laid in same conduit pipe. 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. In our secondary distribution, tree system of supply is mostly utilized. The voltage of each phase to neutral will be maintained at rated value even during the unbalanced load conditions. If neutral wire connection is poor the voltage at each phase will be different from one another, such an isolated neutral point is called floating neutral and the voltage of the point is always changing. This is the reason for over voltage causing damage to appliance's which should be protected. In this paper, a smart system that identifies power leakage and provides over voltage protection to the residential building is proposed.

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

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1. INTRODUCTION

The two main functions of protection devices of electric circuits are consistency and protection. Over current protection scheme is used to detach power supply to circuits which removes fire hazards and electrocution possibilities and thereby protection is assured it. For some products, accurate protection may be required additionally to obey with organization principles. The function of Protection devices is to protect circuits from over voltages or currents. The Electrical power which is generated at the generating station is transferred to consumers at different voltage levels. The electrical wiring of every installation/facility is a calculation oriented process which varies according to the requirements and expectations. Every successful electrical system requires circuit breakers as a part of it. For feeding the main sockets of consumer units, Ring type circuits are used. An important part of wiring system is lighting circuits which are radial in nature [1].

Dedicated circuit breakers are used in heavy duty electrical wiring which are used for high power equipment like HVAC, cookers, heavy duty geysers etc. The following methods are adopted against over voltage protection (*i*) Earthing screen (*ii*) Overhead ground wires (*iii*) Lightning arresters or surge diverters. For residential buildings current sensors, voltage sensors and actuators are used against over voltage protections.

The purpose of electric circuit protection device is the prevention of unnecessary amount of current or a short circuit [2]. There are many devices which are used for the protection of circuits are available in the market such as Fuse, Circuit Breaker, Poly Switch, RCCB, Metal Oxide Varistor, Inrush Current Limiter, Gas Discharge Tube, Spark Gap, Lightning Arrester, etc.

Every electrical installation should have proper grounding connection. The purpose of earthing is to make sure that there is path for the flow of fault current immediately after a fault has occurred which will result in tripping of the main circuit. The grounding prevents the floating voltage condition and hence fatal/non-fatal accidents are avoided. For every domestic/industrial wiring system, a functional earthing system is a must. Consumer units normally comprise of an isolator, miniature circuit breakers, grounding terminals and a circuit path [3]. Fuses and MCBs also disconnect fault from the circuit. Fuses and some MCBs are less sensitive to extreme transient faults; hence these are normally used for lighting circuits. Fuses and MCBs can be considered as the backbone of domestic electrical protection [4]. MCBs are unable to detect residual current (earth leakage current). In order to avoid this problem, Residential Current Circuit Breaker (RCCB) is minimize the risk of injury from electric shock, and are not sensitive to overloads or short circuits. Circuits with RCCB protection must always include separate protection against over loads and short circuits.

The current which flows to the ground is called as leakage current. If there is no connection to the ground, leakage current could flow from any conductive part or the surface of non-conductive parts to ground. In order to provide protection against a shock hazard in case of an insulation failure, a grounding system is normally included with electrical equipment [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

This system identifies the interconnection in neutral wire between any individual consumer's circuit. Once the fault is identified, the alarm is enabled. It also detects high voltage fluctuations and cut off the EB mains supply, protecting appliances from damage. Both alarm & circuit breaking is possible for Interconnection fault & high voltage conditions. This system mainly consists of a current sensing device and a voltage sensing device.

Control circuits board consist of LM324IC which detects signals from voltage & current sensing devices. In order to reduce fault caused by electrical leakage, it is important to detect faults effectively and shut off the power. The protective devices detect faults and operate circuit breakers and other devices to limit the loss of service.

2.1 System Design

The block diagram of proposed system is shown in *Figure 1* which mainly consist of two energy meters namely, energy meter consumer "A" & "B" which gets input power supply from EB mains.

The energy meter "A" is connected to a Contactor and Load and in between energy meter & contactor, current transformer and potential transformers are connected for current, voltage sensing respectively. The output of energy meter is connected to load "B". A neutral interconnection switch is connected between loads "A" & "B".

The current transformer monitors the neutral leakage current and output signal of CT is fed to OP-AMP section and driver unit. In normal condition the neutral interconnection switch is kept open and power flow is read out by both energy meters. When the neutral interconnection switch is closed, the neutral current flowing through the neutral wires gets collapsed and both the energy meters are erratic. If the consumer "A" has no load or minimum load consumed, but the energy meter reads fault reading i.e. higher reading than the actual consumption, the power leakage alarm indicates the leak. The activation of the contactor can be selected to avoid disruptive tripping [8].

For overvoltage protection, the potential signal from the transformer is sent to the comparator and driver unit. During the high voltage condition, the overvoltage alarm is activated and the contactor is interrupted by the relay driver, protecting the devices from damage [9].

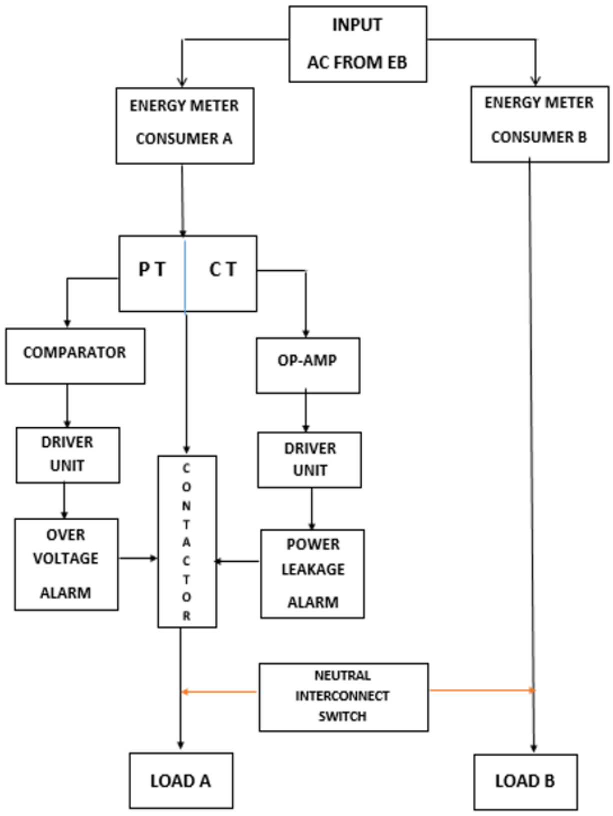

Figure 1: Block diagram of the proposed system

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*.

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 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].

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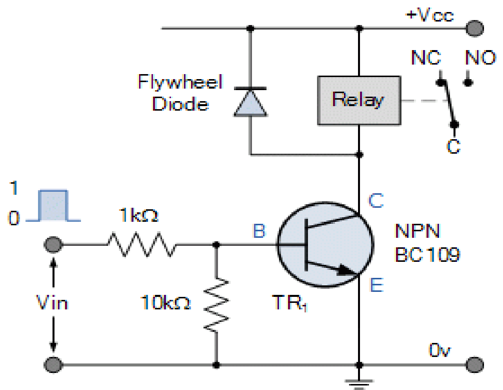

Figure 3: Relay Switching Circuit

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 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].

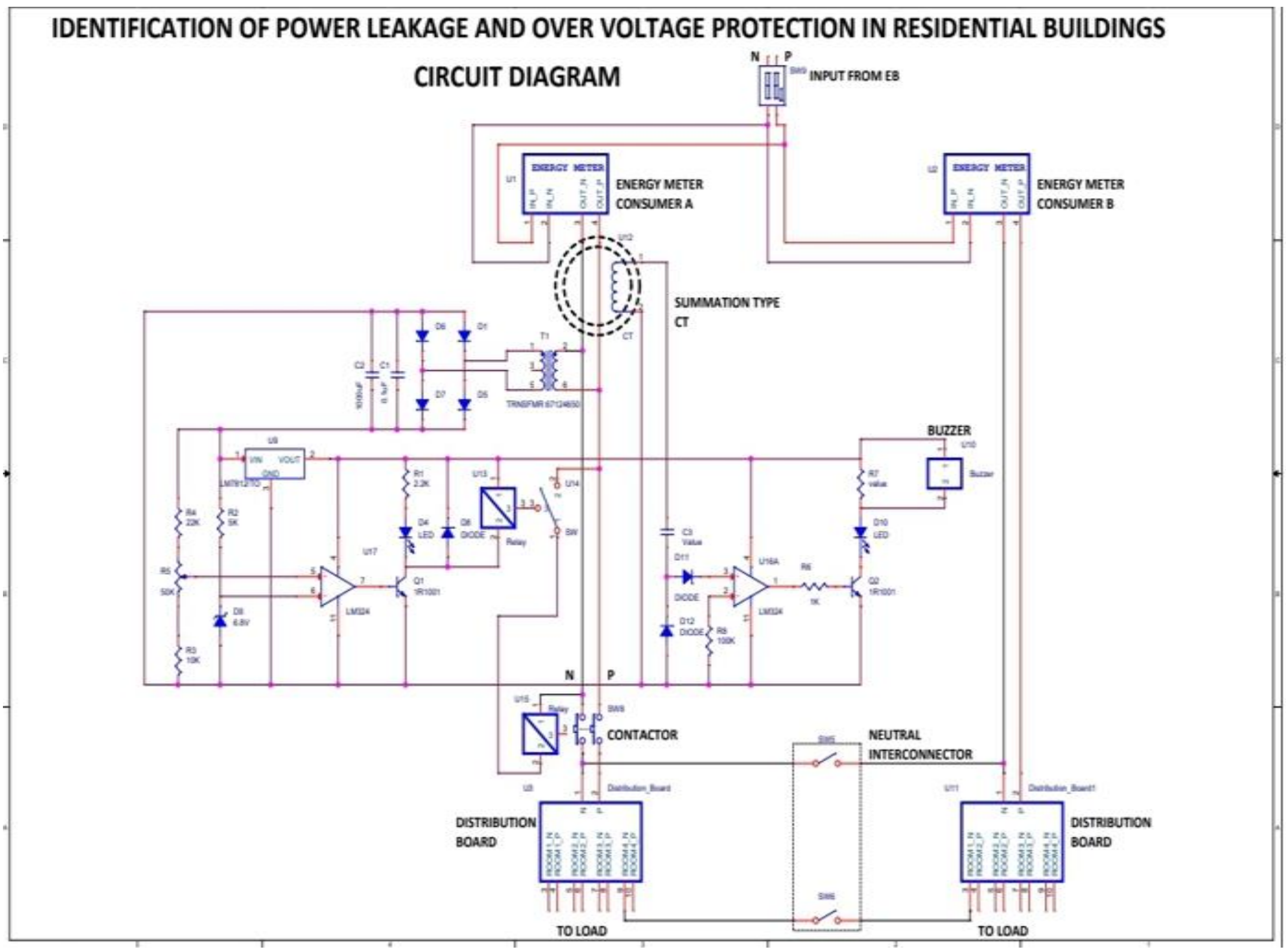

Figure 4: Detailed Circuit Diagram

When Interconnection switch is closed, the neutral connection is collapsed and both energy meters' readings are erratic. The consumer "A" at no load condition, the energy meters shows reading which is reflected from energy meter "B" which is consuming some load. The fault occurred in energy meter reading is due to neutral inter connection. In this condition the power leakage is observed by CT and sensed signal is amplified in op-amp section and drives the driver unit to turn on relay and buzzer unit [12]. The relay unit controls the contactor coil for main circuit open/close if necessary. Consumers are warned by buzzer audio and able to find the fault in their electrical circuit and

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further by switching MCB in DB one by one until buzzer audio stops, to find exactly in which room or connection the fault occurred [13]. Then the fault in the wiring system should be solved by qualified personat the earliest. A potential transformer is connected in the circuit, where the primary side gets raw power from energy meter output, i.e. 230V ac voltage. The secondary side of transformer is step down winding where the voltage in step down to 18 v and given to rectifier section, which consist of 4 diodes connected in the form of bridge [13]. Here the AC voltage is converted to DC and then the impure DC is filtered by capacitor 1000mfd to get pure DC voltage [14].

The voltage is given to regulator 7812 and high voltage protection circuit. The output of 7812 is the power supply for entire circuit including power supply of LM324 IC and relay driver units. The bridge rectifier output voltage is given to the 5th& 6th pin of LM324 IC through resistor R2, R3, R4& R5 respectively such that pin 6 is set to 6.8V with Zener diode D9 connected. The op-amp is used here as a comparator where the voltage is compared and output will be high/low according to voltage in input section.

The voltage parameter is adjusted in resister R5. During high voltage condition i.e. when input voltage crosses 260 V the comparator output pin 7 drives the transistor Q1 to turn on relay unit &buzzer. The relay controls the contactor SW8 to disconnect main supply and protect home appliances from damage [15-17].

For both Neutral leakage and over voltage faults the contactor SW8 turned ON/OFF as per the fault occurred and individual alarm notification through buzzer and led indication is done [18]. As for Neutral interconnection fault, red led indication with time delay buzzer sound is enabled and for over voltage fault red led indication with continuous beep sound [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.

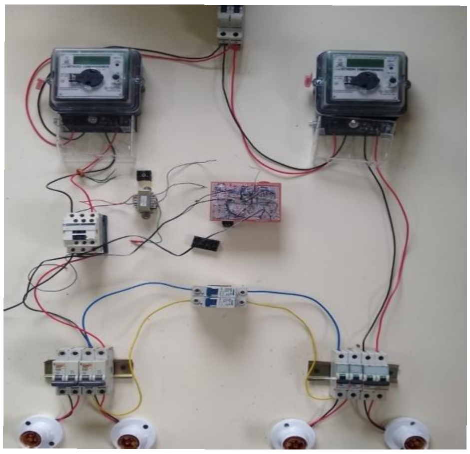

Figure 5: Circuit Implementation

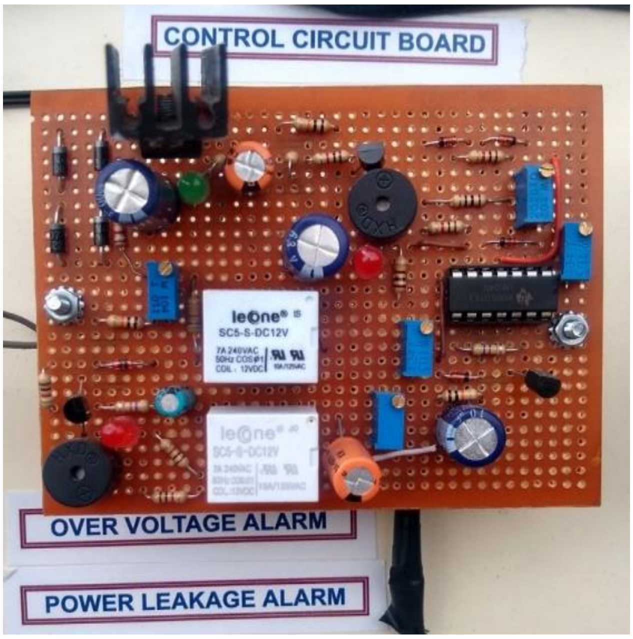

Figure 6: Control Circuit Board

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 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

Common people easily know that there is no power leakage in their home with the help of this device. If there is any power leakage, the device identifies and indicates the power leakage to the consumer visually and audibly. It creates awareness to the consumer to rectify the fault with the help of a technical person. The device also helps the technical person to find the location of the fault easily. It helps the consumers to maintain the electrical system healthy in every house.

The consumers can pay real energy consumption bills and save their money. The consumer will be satisfied with proper and accurate energy measurement with the help of our device and the digital energy meters. The consumer knows that the bill according to their usage is reasonable. Therefore, the billing related problems between the consumer and the supply company are solved using the above device.

By using our device, the billing related complaints are automatically reduced to minimum level. Therefore, the supply company can use the time to serve better to other consumer's complaints. It saves money because unnecessary meter change due to wrong observations leads to waste of money. The saved money is used for many other useful development projects of Supply Company. Here we can build a good relationship between the consumer and the supply company. Since it is a small thing, it helps to solve the major problems.

Conflicts of interest

The authors have no conflicts of interest to declare.

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