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Elimination of Electric Shocks through Dual Voltage Switching Supply System

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Abstract*— Electricity has become one of the fundamental needs of man in modern days, drifting every human from natural environment to a completely electrical environment. In spite of its vast applications one has to agree with the deadliness and the threat we face from electricity. There are several types of protection schemes used to protect ourselves from electric hazards. Among them, the most effective means is the isolation transformer based protection; however this proves to be costly in case of multiple loads. The proposed replaces isolation transformer with a power electronic circuit, thereby reducing the cost, size, losses and chances of electrocution compared to conventional protective schemes.

***Index Terms*— electric shocks and hazards, protection schemes, earthing**

I. INTRODUCTION

Electricity is ubiquitous in today's environment. Special arrangements have to be made in order to keep them away from the human reach to avoid electric shocks. In spite of several steps taken a large number of electrical accidents take place even now.

A. Current and Its Effects on Human Body [6, 7, 8]

The effect of current on a human body is dependent on two factors. The Magnitude of current passing through the body and the duration for which the current is passed. A brief Statistics of deaths and accidents due to electricity every year is given below [10]

TABLE I .MAGNITUDE OF CURRENTS AND ITS EFFECT ON HUMAN BODY

Magnitude of current	Effect in human body
0.5mA	Perception
10mA	Muscular contraction
40mA	Burns , Respiratory arrest
80mA	Severe burns, ventricular fibrillation
1A	Cardiac arrest

- 25% of all fires occur due to electricity source NFPA(National Fire Protection Association)
- 411 deaths from job related electrical accidents per year
- NIOSH (National Institute Of Occupational Safety and Health)
- Electrocution - the fifth leading cause of death (1982 - 1990) NIOSH (National Institute Of Occupational Safety and lth)
- About 12 deaths due to electrocution NCRB(National Crime Records Bureau, India)
- 42 % of total fires occur due to electrical sources Source –OISD(Oil Industry Safety Directory)
- 8% deaths that occur in Indian factories are due to electricity

B. Continuity in a circuit

We all know that current flows from a higher potential to lower potential, but in a TV remote two batteries are connected in series and the +ve terminal of the 2nd battery is connected to the –ve terminal of the first battery and still no current flows unless the circuit is closed externally.(Fig.1)

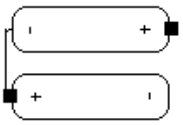

Fig 1 continuuty in a circuit .

Here the reason why current did not flow is that there is no closed path for a current to flow .Hence it can be inferred from here that even though a higher potential is connected to a lower potential there must be an another closed path which again connects these two in order to create a closed path.[3]

C. A Common Mistake

The ground symbol, in many cases, has been taken as a generic symbol in electronic circuit diagrams to represent the current return path, even though no physical earth ground is used. This can cause some confusion to the novice engineering student when using instruments having an earth ground terminal. The following figure shows the front panel of a typical power supply. The supply is represented as a variable voltage battery. Note that three terminals are shown: a positive, a negative, and a ground terminal. The ground terminal of the supply is tied to the case of the instrument, which in turn is wired to a true earth ground such as a water pipe. Let's look at the load connection in the figure. Using the positive terminal of the battery and the ground terminal does not complete a current return path to the energy source (battery), so no current will flow from the source, i.e. I load = 0.(Fig.2)

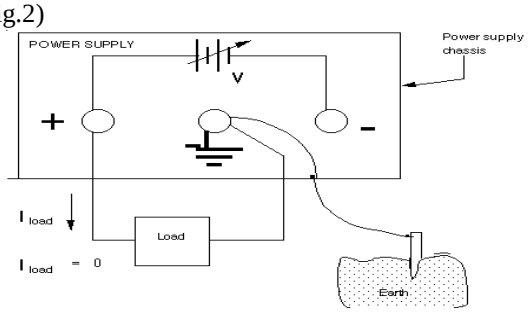

Fig 2 Negative terminal without return path.

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The positive and negative terminals must be used to have a return path exist. For the above circuit to have a current to flow the negative terminal of the battery should also be connected to the earth. Now that the negative terminal of the battery is also connected to the earth, there is a closed path for a current to flow. (Fig .3)

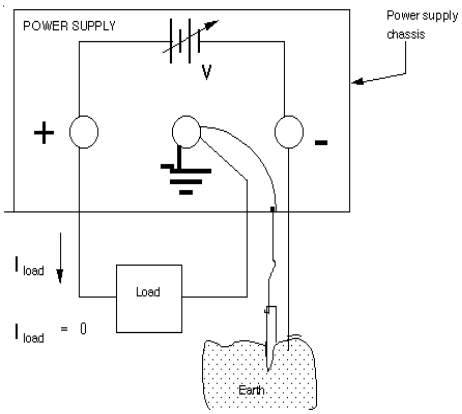

Fig 3. Negative terminal with return path.

D. Reason for shock

Despite the above inference we still get shocked when we touch the phase wire of a supply where the phase is the higher potential and the ground is the lower potential. But where is the closed path that completes the circuit. The key here is that the ground does not act as the lower potential but as a conductor that connects the neural terminal of the supply to the load. From the picture it can be seen that the ground is used as a conductor to complete the circuit.

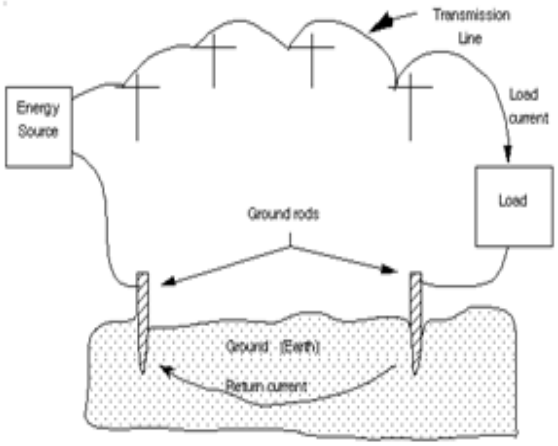

Fig 4 .Transmission system using ground as return path.

E. Need for grounding [11]

When the load circuit uses a metal enclosure, resistive leakage paths can exist which result in high voltages between the enclosure and earth ground. (Leakage is any unsuspected, unwanted resistive path between two points.) If, a earth-grounded object, such as a water pipe, and the enclosure are simultaneously touched by a man, a serious shock will result. Such a condition is illustrated [12] in figure 5.

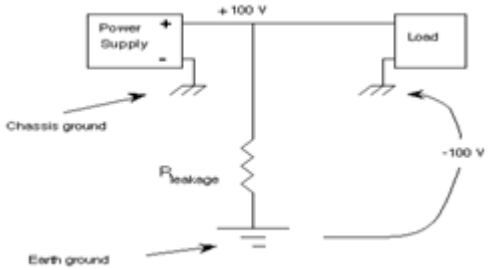

Fig 5 Shock hazards caused by leakage path.

The earth ground is connected to the load enclosure, placing the ground and the enclosure at the same potential, eliminating the shock hazard. Similar hazardous conditions can develop in the installation of household appliances. This is the reason that electrical codes require that appliance frames such as washers and dryers be connected to earth ground. This method of eliminating a shock is prevalently used everywhere in the present electrical systems.

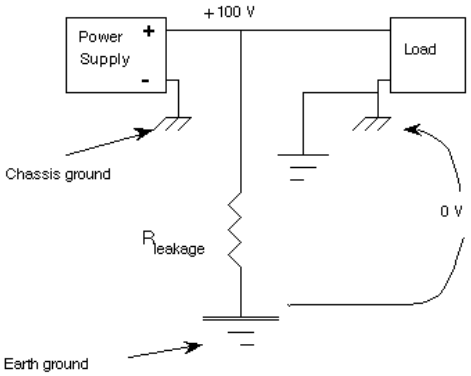

Fig 6 Enclosure of load and earth at same potential.

F. Draw backs of the old method

From the above method the shocks can be eliminated only on a single condition[1,2], i.e. when the neutral terminal is connected to the ground and that the conductor has a resistance less than that of the body which makes contact with the supply.

There are many drawbacks in this method, they are

1. There is no elimination of shock in case of direct contact with the supply.
2. In case a high voltage carrying transmission is cut and is lying on the ground the surrounding area is completely prone to shock (where the range of shock is determined by the voltage carried by the line)

II. SHOCK ELIMINATION USING THE PROPOSED TECHNIQUE

The above method of shock elimination is that current always chooses a path of least resistances .But the following method is based on a principle that current cannot flow unless it gets a closed path as illustrated before.

So in order to eliminate a closed path the grounding of the source is removed, and as we already know we have a phase and a neutral line for current to flow through as in the following case.

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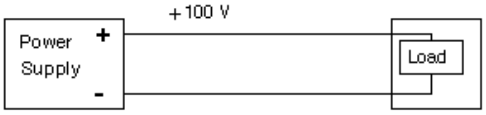

Fig 7 Power supply without grounding.

Now that the load is being operated well even in the absence of the ground there could be some questions about the safety of the system. Here it should be noted that the source is also not grounded. Hence even if there is a resistive path which connects the phase and the ground there is no closed path for a current to flow through. Hence current cannot flow through a person who is holding the phase terminal of the supply.

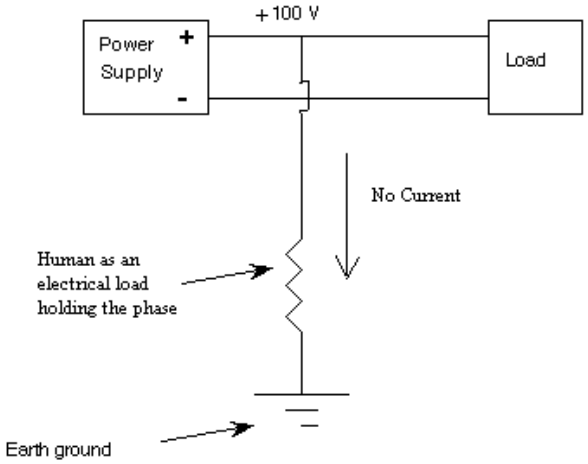

Fig 8 Equivalent circuit of the resistive path connecting the phase and the earth..

The above circuit is analogous to the following circuit.

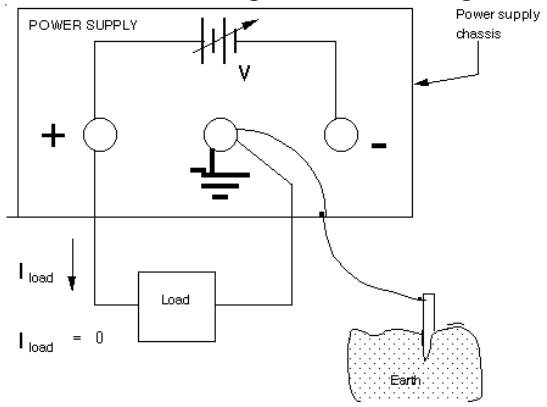

Fig 9 The resistive path connecting the phase and the earth.

As no current flows through the resistive path connecting the phase and the earth, the possibilities of getting shocked is eliminated. [14]

A. Making the Circuit Practical

Even though the above method seems to be simple it requires a sound knowledge to implement it practically. Here not only safety but all the other requirements of a ground must be met with in order to use this technique. Because in a communication stream the ground is used as a filter, that is in order to eliminate the noise the ground is used, so to use this method of safety here a suitable alternative for suppression of noise must be designed and then this technique must be adopted.

But this method can be very easily implemented in places where the need for a ground terminal is only "safety". In domestic areas for household purposes the ground terminal is used only for "safety". Hence this method of shock elimination can be easily and effectively implemented in a house hold area.

In order to implement this method an ungrounded supply is needed which is very hard to develop in each and every area, so instead of going for an ungrounded supply we can make an isolated electrical supply or system from the available power source and use it as an ungrounded supply. Now that we have an isolated supply with us we can connect this supply with our load without grounding the supply so that without a closed path current cannot flow through a person touching even the phase line.

B. A practical problem:

The above method seems to be very simple but there is a very basic practical problem that puts a great trouble in going further. The problem occurs only when we go for multiple loads but it's quite simple for a single load. The problem is that when there are multiple loads present, there is a probability that when one person holds the phase of the supply there could be another person holding the neutral terminal and standing in the ground at the same time. So the circuit gets completed through the two people standing in the ground and the ground itself, hence the two persons get shocked .the probability that this kind of shock can occur, lies with the number of loads connected to the supply.[13]

C. Isolating supply terminals:

The above problem can be eradicated by means of isolating each and every load electrically from each other. For this electrical isolation there are two possible solutions. They are

- Using Isolation Transformers
- Using a power electronic circuit

D. Using isolation transformers

Using an isolation transformer is an effective and a safe way for the isolation of the load from each other but the problem is that for individual loads individual isolation transformers must be implemented which makes the cost of a multiple load electrical system to be very costly. Hence this system cannot be adopted.

E. Using a power electronic circuit:

A power electronic circuit can be used as a substitute for an isolation transformer for isolating a load electrically. The fact is that electronic circuits are quite cheap when compared to the conventional transformers and their efficiency is also comparably greater than that of the transformers. The following circuit can be used to isolate an electrical load from others. This circuit takes two inputs i.e. phase and neutral and gives two outputs which are also phase and neutral

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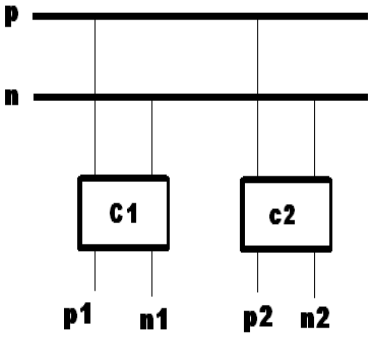

Fig 10. Isolation circuit

The difference between the input and the output is that the current from p1 can only enter n1 and not n2, the same way the current from p2 can only enter through n2 and not through n1. So here the practical problem discussed previously can be eliminated i.e. if a man is stands holding p1 and another man holding n2, the current from p1 cannot enter n2 , so there is no closed path between these two persons hence no current flow also. So this kind of isolation provides a shock proof environment even with multiple loads at low cost of implementation.

The following circuit can give the required functionality described above.

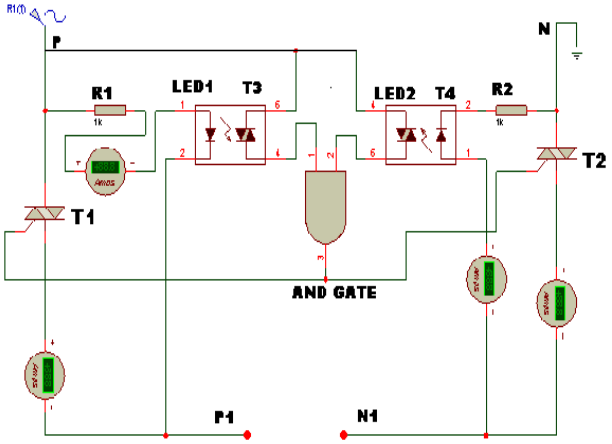

Fig 11 proposed topology.

F. Circuit operation:

There are three possible modes of operation for the above circuit .They are as follows

- P1 and N1 are connected to each other through a load
- P1 is connected to an external ground
- N1 is connected to an external phase

The operation during each mode is described below.

III. MODES OF OPERATION

A. P1 and N1 are connected to each other through a load

Here when the load is connected between P1 and N1 the circuit gets into the conduction phase. When the load is connected current initially flows through

P1->R1->LED1->LOAD->LED2->R3>-N1

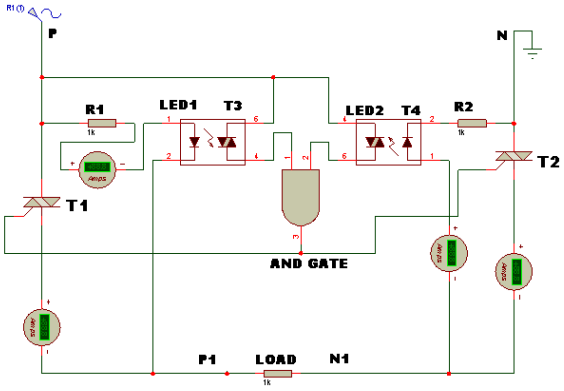

Fig 12 P1 and N1 are connected to each other through a load.

Here current cannot take any other path initially because all the 4 TRIACs are in OFF state [4]. In the above current path when sufficient current flows through the two LEDs they trigger TRIAC3 and TRIAC4, so a high input is given to both the terminals of the AND gate. So the output of the AND gate [5] is also HIGH which in turn triggers the TRIAC1 and TRIAC2 which gives a low resistive path for the current to flow through the LOAD. Now the path of the current is as follows

P1->T1->LOAD->T2->N1

Hence the total power input is delivered to the load in this phase after a time of 0.3micro seconds after connecting the load.

B. P1 is connected to an external ground:

When P1 is connected to an external ground say N then the following circuit operation takes place. Initially the current takes the path as

P1->R1->LED1->LOAD->N

In the above current path only LED1 glows and hence only TRIAC3 conducts. The input to the AND gate is 1 and 0 so the output of the AND gate is 0. Therefore TRIAC1 and TRIAC2 are sat off state and the power delivered to the load is very low as R1 is very high.

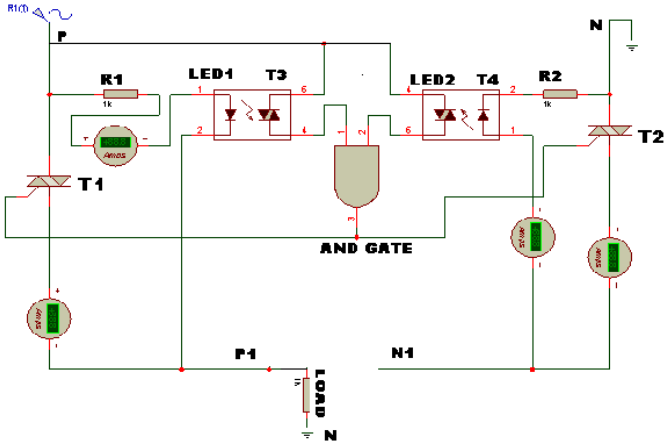

Fig 13 P1 is connected to an external ground.

C. N1 is connected to an external phase

When N1 is connected to an external phase say P then the following circuit operation takes place. Initially the current takes the path as

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P->LOAD->LED2->R3->N1

In the above current path only LED2 glows and hence only TRIAC4 conducts. The input to the AND gate is 1 and 0 as earlier and so the output of the AND gate is also 0 as seen. Therefore TRIAC1 and TRIAC2 are still at off state and the power delivered to the load is very low as R3 is very high when compared to the LOAD.

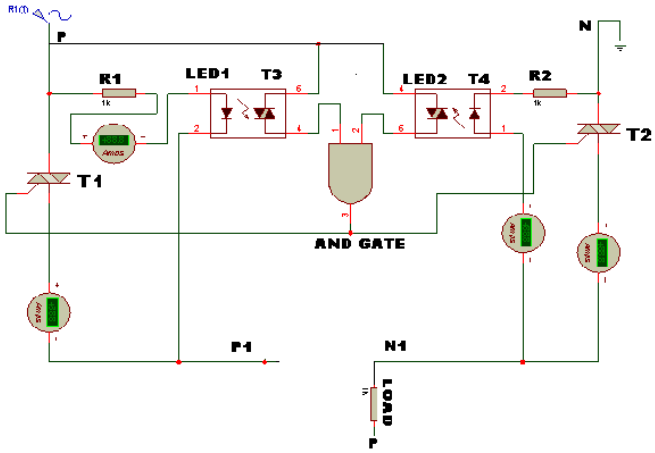

Fig 14 N1 is connected to an external phase.

IV. DISADVANTAGES OF USING POWER ELECTRONIC CIRCUIT ISOLATION

[1]To ensure safety each and every load must be connected to one IC.

[2]Ground terminals must be disconnected which requires manual work.

V. TOTAL IMPLEMENTATION

For this safety mechanism to operate efficiently the following rules must be followed

- The main input supply for the whole system must be connected to a single isolation transformer.
- Each and every load must be connected to the supply through the above described IC.
- The ground connection to all the loads must be disconnected.

With the above method of safety implemented the only possibility of getting shocked is to hold both the phase and neutral from a single plug point making yourself as a path to flow. If any one of these conditions fails then there can never be a shock!

VI. CONCLUSION

The proposed method of protection decreases the probability of getting an electric shock and the precautionary while handling electricity such as wearing safety gloves and rubber boots. Thus taking electrical environment to a safer zone for all including children.

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