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Technical Innovation of Contactor Applications (TICA)

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Abstract: The idea here is slightly different from the general applications of contactor to electrical circuits, the said device is commonly used to make and to break electrical circuits automatically, it works for both single Phase and three Phase circuits, the difference between circuit breakers and contactors is that circuit breaker could only break automatically but cannot make until it is manually controlled, while contactors could. The technical innovation is the uncommon application of electrical contractors which are the switching off of generator when mains arrived and the ability to display indicators belonging to mains, generator and the load. Technical connectivities between the mains, generator and the load of contactor. The advantage of the connectivity is that the user will not need to get up to put off generator and to change over manually. All of that has been taken care of by the set up. The Prototype of the setup has been designed and constructed for result. Contactors are useful in commercial and industrial applications for controlling large lighting loads, for controlling motors, for fast changing over between electrical power sources and for Interconnectivity in power plants. Users of contactors will not have to move about to switch off generator and to change over power to mains when it is available, there will be no need for manual changeover device, working electrical and electronic devices would not be interrupted and one of their hallmarks is reliability. Contactor does not simply wear out from normal use. It prevents user from electric shock and there is no earthing.

Keywords: Mains Make, Break, Contactor, Single Phase, Three Phase, Technical Connectivity, Prototype

1. Introduction

A contactor is an electrically-controlled switch used for switching an electrical power circuit. A contactor is typically controlled by a circuit which has a much lower power level than the switched circuit, such as a 24-volt coil electromagnet controlling a 230-volt motor switch. There are different types of electrical Contactors for different purposes but the contactor in question is 3TB42 22-OX made by SIEMENS. A contactor really has only two basic parts: the contacts and the coil. Electrical contractors were made to perform certain functions in electrical circuit [1, 2]. The contactors are manufactured in their different shapes and sizes; it all depends on design specifications. The available holes for connections on electrical contractors vary; there are three holes connection type and four holes connection type. The coil energizes the contactor, moving the contacts into position. The contacts transmit the current from the source to the load. Heat can destroy either of them. The following are the features of the said contactor: A1 and A2 for input power [3, 4]. There are four main normally open terminals with two normally close and open terminals on the auxiliary.

A contactor is composed of mainly hard plastic, silver and copper. Contactors are useful in commercial and industrial applications, particularly for controlling large lighting loads and motors. One of their hallmarks is reliability. However, like any other device, they are not infallible. In most cases, the contactor does not simply wear out from normal use. Usually, the reason for contactor failure is misapplication [4, 5]. That is why you need to understand the basics of contactors. When someone uses a lighting contactor in a motor application, that's a misapplication. The same is true when someone uses a "normal operation" motor contactor for motor jogging duty. Contactors have specific designs for specific purposes [6]. I have therefore used a single contactor to achieve as follows: interconnectivity of two single phase electrical power sources (Power Holding Company of Nigeria and a Generator).

The use of electrical contactors for this level of switching application is not common but literatures researched for this result cannot be ignored. The Purpose of electrical contactors in electrical circuit is to transmit electrical power from the power source to electrical load with the use of electrical cables. History of contactor began with the formulation of Maxwell in 1862 where he described phenomena of Power transfer. Nikola Tesla investigated the principle of power Transfer (PT) at the end of the 19th century.

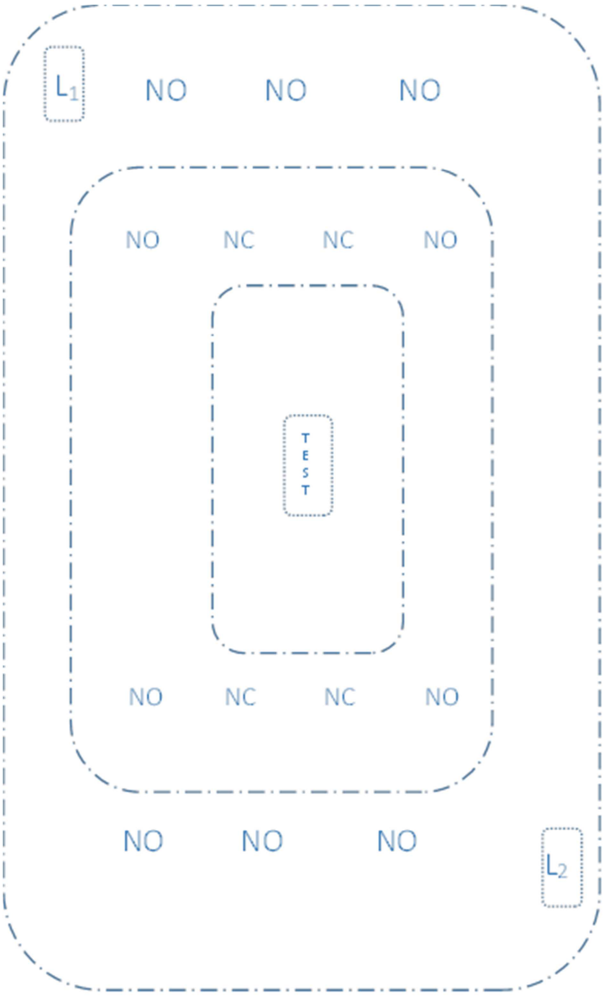

Figure 1. *Skeletal View of a Contactor.*

Tesla's experiment was not exploited to a commercial level because of its seemingly unsafe nature, low efficiency, and financial constraints in development and performance evaluation of a contactor power supply system for electrical appliances. Another application by Showa Aircraft Industry (SAI) in Japan collaborated with Waseda University. An alternative technology that proffers solutions as regards limitation of contactor Power Transfer (CPT) was provided by the study of Karalis and colleagues at the Massachusetts Institute of Technology (MIT). Contactor uses one set of coils and the power is delivered between the four or three contacts. The figure below delivers up to 75kw built with suppressors and auxiliary contacts.

A contactor has three components. The contacts are the current-carrying part of the contactor. This includes power contacts, auxiliary contacts, and contact springs. The electromagnet (or "coil") provides the driving force to close the contacts. The enclosure is a frame housing the contacts and the electromagnet. Enclosures are made of insulating materials such as Bakelite and thermosetting plastic. To protect and insulate the contacts and to provide some measure of protection against personnel touching the contacts. Open-frame contactors may have a further enclosure to protect against dust, oil, explosion hazards and weather. Magnetic blowouts use blowout coils to lengthen and move them to protect and insulate the contacts and to provide some measure of protection against personnel touching the contacts.

Figure 2. *Pictorial Top View.*

Open-frame contactors may have a further enclosure to protect against dust, oil, explosion hazards and weather.

Figure 3. *A contactor without auxiliary.*

1.1. The Arc

Magnetic blowouts use blowout coils to lengthen and move the electric arc, these are especially useful in DC power circuits. AC arcs have periods of low current, during which the arc can be extinguished with relative ease, but DC arcs have continuous high current, so blowing them out requires the arc to be stretched further than an AC arc of the same current. The magnetic blowouts in the pictured Albright contactor (which is designed for DC currents) more than double the current the contactor can break, increasing it from 600 A to 1,500 A. Sometimes an economizer circuit is also installed to reduce the power required to keep a contactor closed.

1.2. Auxiliary Circuits

Sometimes an economizer circuit is also installed to reduce the power required to keep a contactor closed; an auxiliary contact reduces coil current after the contactor closes. A somewhat greater amount of power is required to initially close a contactor than is required to keep it closed. Such a circuit can save a substantial amount of power and allow the energized coil to stay cooler. Economizer circuits are nearly always applied on direct-current contactor coils and on large alternating current contactor coils. A basic contactor will have a coil input (which may be driven by either an AC or DC supply depending on the contactor design).

The coil may be energized at the same voltage as a motor the contactor is controlling, or may be separately controlled with a lower coil voltage better suited to control by programmable controllers and lower-voltage pilot devices. Certain contactors have series coils connected in the motor circuit; these are used, for example, for automatic acceleration control, where the next stage of resistance is not cut out until the motor current has dropped when current passes through the electromagnet a magnetic field is produced, which attracts the moving core of the contactor.

The electromagnet coil draws more current initially, until its inductance increases when the metal core enters the coil. The moving contact is propelled by the moving core; the force developed by the electromagnet holds the moving and fixed contacts together. When the contactor coil is de-energized, gravity or a spring returns the electromagnet core to its initial position and opens the contacts [5]. For contactors energized with a small part of the core is surrounded with a shading coil, which slightly delays the magnetic flux in the core. The effect is to average out the alternating pull of the magnetic field and so prevent the core from buzzing at twice line frequency.

Because arcing and consequent damage occurs just as the contacts are opening or closing, contactors are designed to open and close very rapidly; there is often an internal tripping point mechanism to ensure rapid action. Rapid closing can, however, lead to increase contact bounce which causes additional unwanted open-close cycles. One solution is to have bifurcated contact.

1.3. Arc Suppression

The electric current arcing the occurrence of causes significant degradation of the contacts, which suffer significant damage. An electrical arc occurs between the two contact points (electrodes) when they transition from a closed to an open (break arc) or from an open to a closed (make arc). The break arc is typically more energetic and thus more destructive. The heat developed by the resulting electrical arc is very high, ultimately causing the metal on the contact to migrate with the current. The extremely high temperature of the arc (tens of thousands of degrees Celsius) cracks the surrounding gas molecules creating, ozone, carbon monoxide.

Most motor control contactors at low voltages (600 volts and less) are air break contactors; air at atmospheric pressure surrounds the contacts and extinguishes the arc when interrupting the circuit [2-5]. Modern medium-voltage AC motor controllers use vacuum contactors. High voltage AC contactors (greater than 1,000 volts) may use vacuum or an inert gas around the contacts. High voltage DC contactors (greater than 600 V) still rely on air within specially designed arc-chutes to break the arc energy. High-voltage electric locomotives may be isolated from their overhead supply by roof-mounted circuit breaker. Inductor is part of a contactor without which there will be no pulling strength.

Figure 4. *Pictorial view of the coil.*

1.4. Electromagnetic Fields Exposure

Electromagnetic field exposure (EFE) is a major concern for wireless charging of Electric Vehicle's battery. Electromagnetic field exposure (EFE) exposure need to be rigorously analyzed to be within acceptable levels specified by safety standards both under normal conditions as well as unusual conditions such as during abnormal operation. For the driver and passengers in the car, the radiation hazard may be less concerned due to the shielding of metal on the chassis of the car. However, there is a possibility that humans or animals may be present underneath the car during charging and therefore be exposed to high levels of electromagnetic radiation.

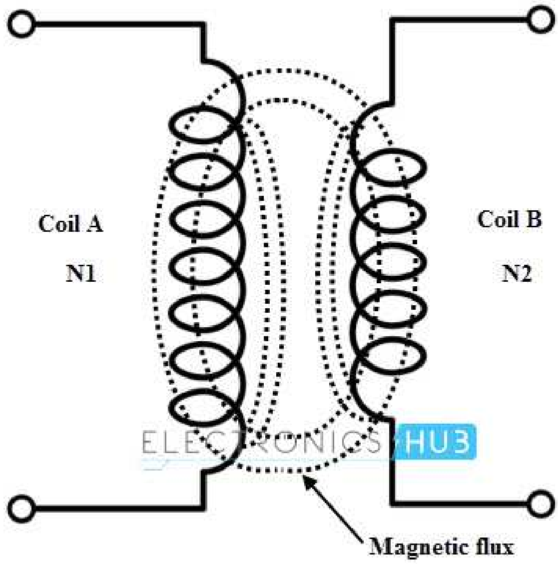

Figure 5. *Electromagnetic Radiation.*

1.5. Radiating Field Between Coils with

Reference to Electric Vehicles

The radiating field as in briefly narrates the behavior of the device:

1. The mains voltage is converted into high frequency alternating current.
2. The alternating current is sent to the transmitter coil by the transmitter circuit.
3. The alternating current flowing within the transmitter coil creates a magnetic field which extends to the receiver coil (when within a specified distance).
4. The magnetic fields generate current within the receiver coil of the device.
5. The current flowing within receiver coil is converted into direct current (DC) by the receiver circuit, thus charging the battery of the device.

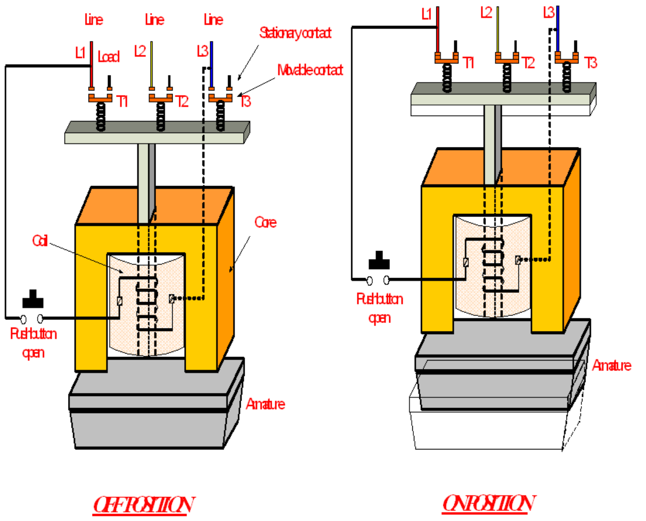

Figure 6. *Explode view of on and off Position of an electrical contactor.*

The wireless system relies on the well-known principle of electromagnetic induction. A magnetic field generated by an alternating current in a primary coil induces a current in a nearby secondary coil. What is new is technology that allows for an energy-transfer efficiency of 90 per cent or higher. Engineers John Boyes and Grant Covic at the University of Auckland in New Zealand worked out the optimal design for the shape of the coils to minimize energy losses. They also figured out how power can be transferred when the coils are misaligned – so it still functions even if you are terrible at parking. The magnetic field has to be controlled so it stays within a safe limit, otherwise metal carried by passengers, from coins to pacemakers, could heat up. Two firms – IPT Technology of Efringen-Kirchen in Germany and Qualcomm Halo of London – have licensed the Auckland patents and are developing their own variants. On 9 January, the UK city of Milton Keynes launched a full-scale electric bus service, plying a 24-kilometre route with eight buses running from the city center to Bletchley, charged using IPT's pads. Two of the stops my bus arrives at have power coils embedded in the ground and covered by $3m^2$ toughened pads.

Using markings on the road and kerb, the driver aligns the bus, with its pickup coil fitted underneath, over the pad to establish a magnetically coupled link. And that's it: after some wireless authentication to identify the vehicle, the bus's battery pack gets a 120-kilowatt charge for 10 minutes during a built-in timetable stop. The bus still uses diesel, too, but only for its heating system, says John Miles of London-based firm Arup, who is a consultant on the project. IPT Technology's wireless chargers also supply power to buses on two routes in Genoa and Turin in Italy.

After successfully trialing a wirelessly charged Mercedes electric vehicles (EV), the firm is planning to expand production of its devices for consumer EVs, says product manager Mathias Wechler. Qualcomm Halo is developing 3-kilowatt chargers for the Renault Fluence, a four-door family-size car. They are just 25 centimeters square and 2.2 cm deep, with road pads that are 75 cm square and 3.3 cm deep.

In the next two to three years wireless charging will definitely become an option for EVs," says director Joe Barrett. In a test of the technology's potential, Paul Drayson, a British racing driver and entrepreneur, last October set the world land-speed record for a lightweight EV in a racing car charged by one of Qualcomm Halo's wireless pads.

1.6. Ratings

Contactors are rated by designed load current per contact (pole) maximum fault withstand current, duty cycle, design life expectancy, voltage, and coil voltage. A general purpose motor control contactor may be suitable for heavy starting duty on large motors; so-called "definite purpose" contactors are carefully adapted to such applications as air-conditioning compressor motor starting.

North American and European ratings for contactors follow different philosophies, with North American general purpose machine tool contactors generally emphasizing simplicity of application while definite purpose and European rating philosophy emphasizes design for the intended life cycle of the application.

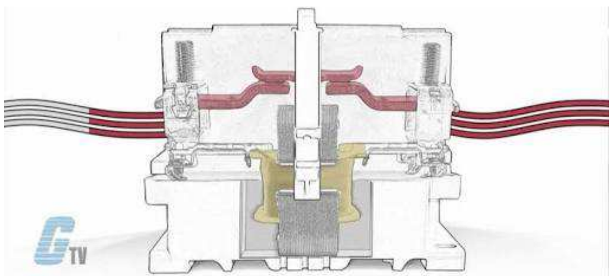

Figure 7. *Contactor rating pole.*

1.7. Block Diagram Components

i. Mains indicator: This indicates that the current source of power is from Power Holding Company.

ii. Generator Indicator: This indicates that the current source of power is from personal generator.

iii. Load Indicator: This indicates that there is power from either source.

iv. Contactor: This is the brain of the system; it is the electrical stationary machine that performs the connectivity function.

v. Connector: This is a means by which the electrical cables are directed and connected.

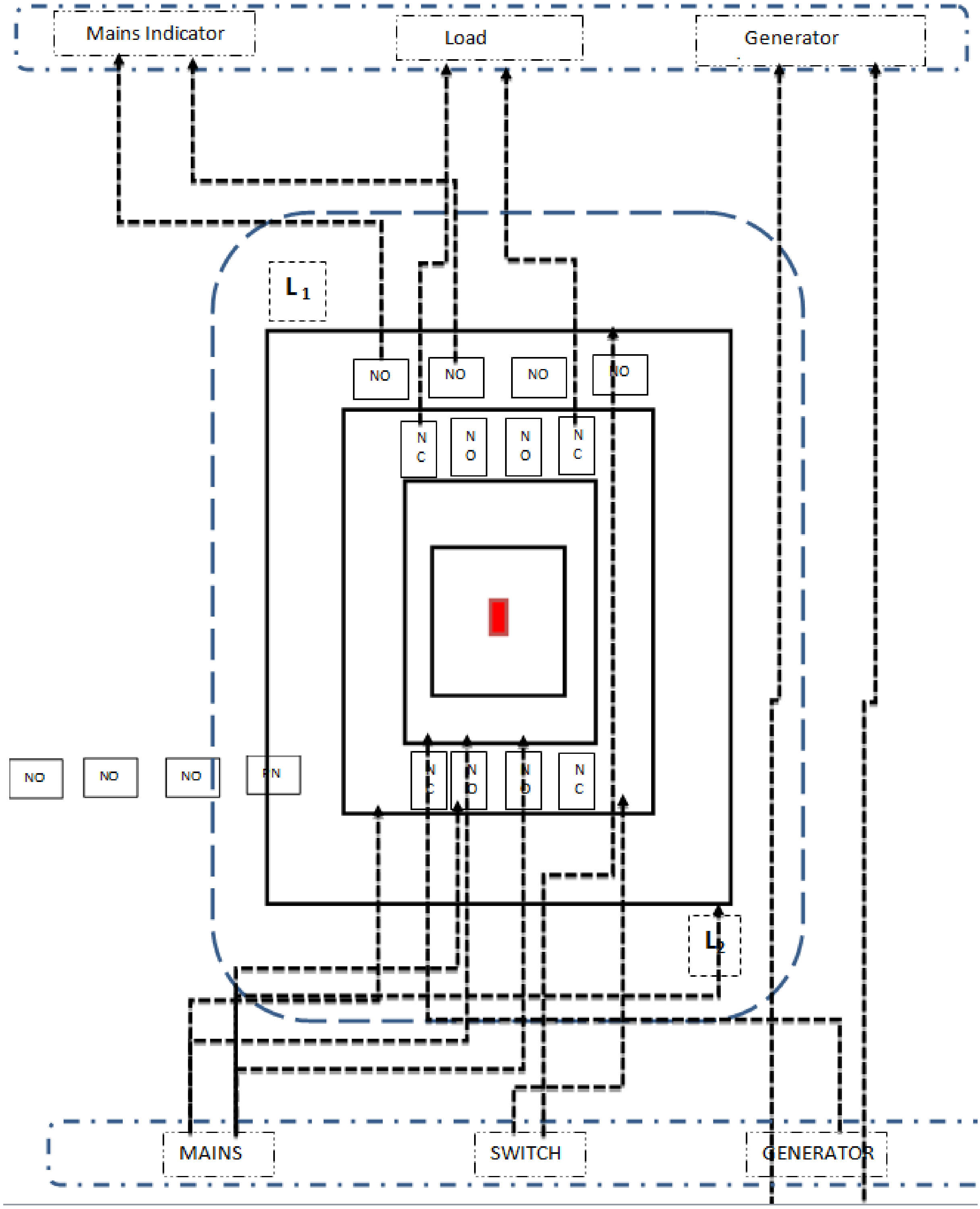

Figure 8. *Circuit diagram for single Phase contactor connections.*

1.8. The Arc and Contact

An auxiliary contact reduces coil current after the contactor closes. A somewhat greater amount of power is required to initially close a contactor than is required to keep it closed. Such a circuit can save a substantial amount of power and allow the energized coil to stay cooler. Economizer circuits are nearly always applied on direct-current contactor coils and on large alternating current contactor coils [7, 8]. A basic contactor will have a coil input (which may be driven by either an AC current or DC current supply depending on the contactor design).

The coil may be energized at the same voltage as a motor the contactor is controlling, or may be separately controlled with a lower coil voltage better suited to control by. These are especially useful in DC power circuits. AC arcs have periods of low current, during which the arc can be extinguished with relative ease, but DC arcs have continuous high current, so blowing them out requires the arc to be stretched further than an AC arc of the same current. The magnetic blowouts in the pictured Albright contactor (which is designed for DC) more than double the current the contactor can break, increasing it from 600 A to 1,500 A. The closeness of inductive materials is very important if effective magnetic field is a target.

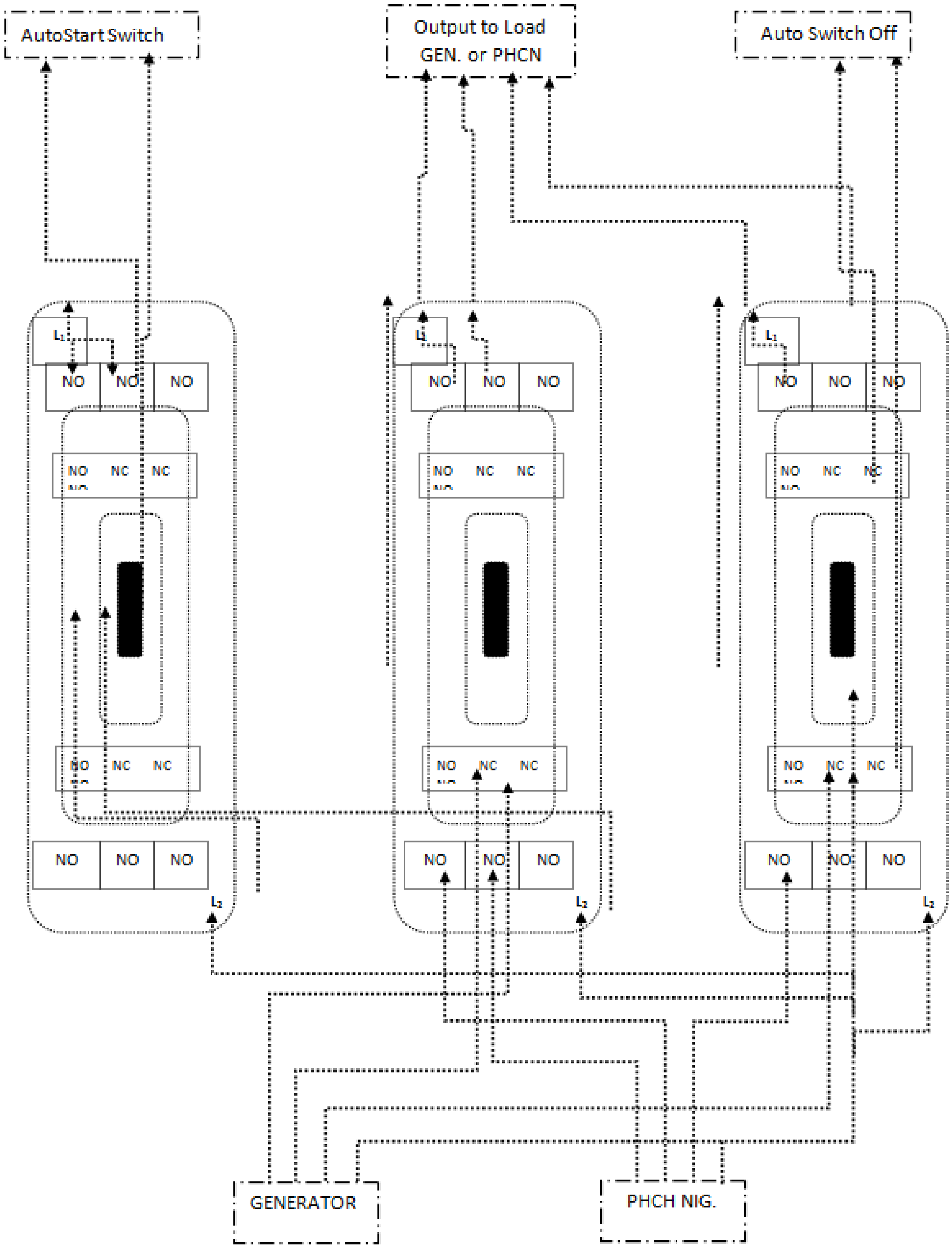

Figure 9. Circuit diagram for three Phase contactor connections.

1.9. Relay

Unlike general-purpose relays contactors are designed to be directly connected to high-current load devices. Relays tend to be of lower capacity and are usually designed for both normally closed and normally open applications. Devices switching more than 15 amperes or in circuits rated more than a few kilowatts are usually called contactors. Apart from optional auxiliary low-current contacts, contactors are almost exclusively fitted with normally open (form A) contacts. Unlike relays, contactors are designed with features to control and suppress the arc produced when interrupting heavy motor currents.

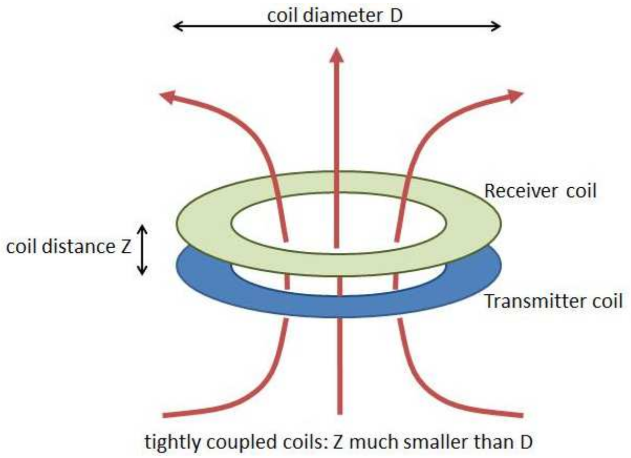

Figure 10. *Loosely couple coil diagram.*

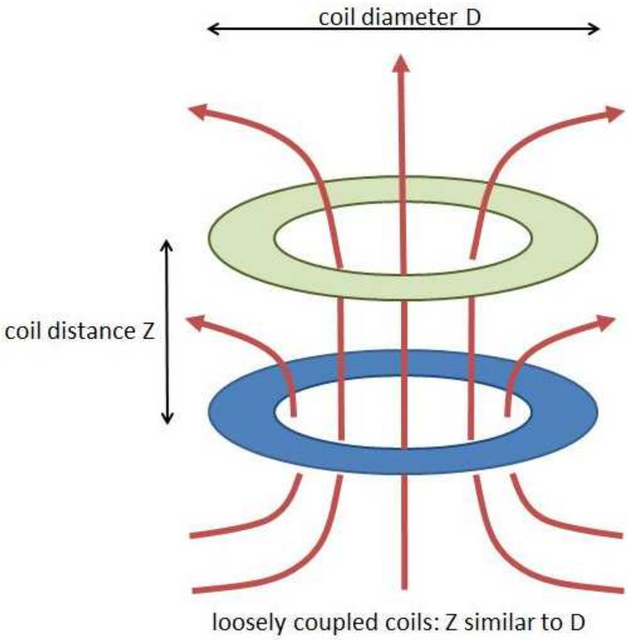

Figure 11. *Tightly couple coil diagram.*

2. Methodology

This is easily demonstrated when the plant or generator is in use and the mains suddenly arrive, the expected actions are switching off of the generator and instant supply of the mains is made without noticing a blink and all appliances remain functional [7-10]. The automatic changeover is carried out at the speed of light; this is due to the technical connectivity. Shown in Figures 12 and 13 are electrical circuit connections made to actualise the single and three Phase circuit.

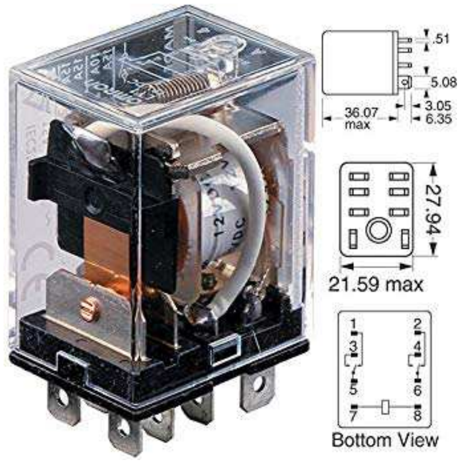

Figure 12. *Relay Diagram.*

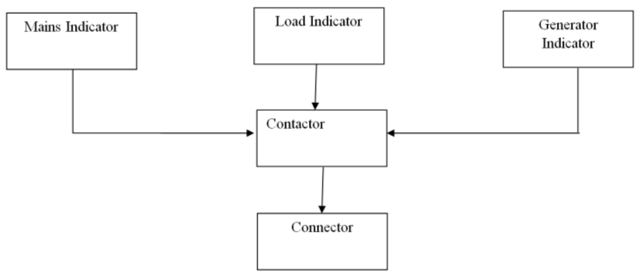

Figure 13. *Block Diagram.*

There is need to be comfortable when it come to power change over issues, the uninterruptible electrical interconnectivity made on a device called contactor is so effective that a working generator could be switched off and the power is changed over without interrupting home electrical and electronic equipment in use, for example an ongoing movie will not stop during change period [11-13].

This is because the speed at which the contactor opens and closes is as fast as the speed of light while the machine was made to control main electrical power circuits. It is available for both single and three phase connections, it has an auxiliary attached to the contactor, both are surrounded with normally open and normally close terminals including two power and switch terminals for perfect operation [14-16].

3. Summary

Contactors are useful in commercial and industrial applications:

i. For controlling large lighting loads.
ii. For controlling motors.
iii. For fast changing over between electrical power sources.
iv. For Interconnectivity in power plants.

The merits of Contactors include:

i. User will not have to move about to switch off generator and to change over power to mains when it is available.
ii. There will be no need for manual changeover device.
iii. Working electrical and electronic devices would not be interrupted.

iv. One of their hallmarks is reliability.
v. Contactor does not simply wear out from normal use
vi. It prevents user from electric shock.
vii. There is no earthing.

The demerits of Contactors include:

i. Difficulty in making when its input power is low.
ii. Interconnectivity does not include starting a generator.
iii. Failure is due to misapplication.
iv. The device cannot is not connected to start a generator for these reasons:
   a) The generator battery power may be low.
   b) There may be shortage of oil in the engine.
   c) The generator start when no one is at home

4. Conclusion

The Contacts of a contactor will overheat if they transmit too much current, if they do not close quickly and firmly, or if they open too frequently. Any of these situations will cause significant deterioration of the contact surface and the shape of that surface.

Coils can overheat if operating voltages are too low or too high; if the contacts fail to open or close because of dirt or misalignment; or if they have suffered physical damage or experienced an electrical short. Coil insulation degrades quickly when it gets too hot.

When it degrades, it will short out (and blow a fuse) or just open and stop operating. However the disadvantages mentioned above can be turned into advantages with further research work.

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