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Construction of an Automatic Distribution Box and Change-Over using A 433 Mhz Radio Frequency Remote Control

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Abstract

The distribution board is a panel that houses the fuses, circuit breakers, and ground leakage protection units used to distribute electrical power to numerous individual circuits or consumer points. The board typically has a single incoming power source and includes a main circuit breaker and a residual current or earth leakage protection device. The core function of any distribution board is to allow individual circuits to draw power from correctly rated circuit breakers and for those circuits to be isolated without causing a disruption to the rest of the supply. The construction of automatic distribution box and change over using a remote control consisting radio frequency module of a distinct frequency of 433MHz, microcontrollers various ICs such as IC HT12E, IC HT12D, IC 74764, IC 74138/4013,IC 74174, a Relay of 12v, 10A, Transistor BC548,Circuit Breaker, Push buttons 4nos. The construction of this multi-channel remote control system can control the 4 different phases of the distribution box. This device was achieved by the use of integrated circuits that has timing abilities and relays to effect switching. The automatic phase change-over switch, however, switches between electrical power supply from public supply to generator in the event of a power outage. Furthermore, both power switching circuit and display unit were designed. ABB-type power contactors rated 12A, 220V A.C was used timer relays to provide some delays (5 seconds) during the starting of the generator and transfer of the connected load vice versa from both power sources depending on the side with steady electrical power at any point in time are used.

Keyword: Distribution Board, Change Over, Circuit Breaker, Automatic, Power Supply.

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Introduction

The advancement of industrialization and various commercial processes hinges on the stability of adequate electrical power supply. Instability in the supply of electrical power in developing countries in West Africa, especially Nigeria, has created a need for alternative sources of power using an automated means to facilitate stability in electrical power generation [1].

Although, developed countries of the world such as Canada, China, Finland, USA e.t.c. have harnessed the stability of power supply leading to a high level of industrialization.

Nigeria as a case study of one of the developing African countries, suffers terrible setbacks resulting from epileptic power supply. This has made the industrial sector of the country to opt-in for the use of alternative power source from generators [2]. It is however imperative to overcome the pressing challenge of manual switching between the conventional power supply and the generators using a manual change-over. This brought about the advent of introducing the automated means of switching between the sources of electrical supply used by many developed countries. This automated means of power supply serves a remedial purpose of ensuring a stable power supply from both power sources and also vital due to increasing demand in electrical energy [3].

As a retrospect to the automated approach, the construction of an automated distribution box became very germane. This board is described as a device which consists of bus bars, switches, fuse links, automatic protective equipment and bypass equipment for connecting, controlling and protecting a number of branch circuits fed from one main circuit of a wiring installation in a building or premises for easy and safe handling of incoming power supply. The applicability of this device is also known in protecting the electrical distribution system from being damaged due to various faults like short circuit, overload and earth leakage [4].

The changeover switch is an electronic device used to switch in between power sources. It works by shutting down a power source and switching on another [5].

The automatic changeover is connected to both power supply sources and supplies the load with power from only one of the sources at any instant in time. In contrast to the manual change-over switch system, that requires manual stress in starting the generator, and switching over from public supply to generator and vice-versa, the need to develop a system that will effectively manage power supply between two sources (utility and a standby power generator),and therefore influence the motivation for this project work. This research is aimed at providing steady and uninterrupted power supply through the construction of automatic change-over and remote-controlled distribution box that switches between generator and electric power supply from PHCN.

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Materials and Methods

Materials

➢ Radio frequency Module

The radio frequency module can be described as a small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system, it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through radio frequency (RF) communication. This electronic device is used as a substitute for older infra-red communication designs as they have the advantage of not requiring line-of-sight operation [6].

➢ Radio Frequency Transmitter Module 433Hz

This is a wireless transmitter which works with 433*MHz* receiver used. The device functions effectively with microcontrollers and fit in well into a breadboard. This enhances the creation of a very simple wireless data link. However, being a transmitter, it will work only by communicating data one-way. You would need two pairs (of different frequencies) to act as a transmitter/receiver pair. These modules receive a fair amount of noise because both the transmitter and receiver work at common frequencies. Hence, noise filtering may not be required. The features of both radio frequency transmitter and receiver module is shown in Table 2.1

Table 2.1.Features of the radio frequency transmitter and receiver module433MHz

S/N	Features of Radio Frequency Transmitter Module 433MHz	Features of Radio Frequency Receiver Module 433MHz
1	433 MHz	Range in open space(Standard Conditions): 100 Meters
2	500 ft range (given perfect conditions)	RX Receiver Frequency: 433 MHz
3	4800 data rate	RX Typical Sensitivity: 105 Dbm
4	5V supply voltage	RX Supply Current: 3.5 mA
5	Working voltage: 3 - 12V for max. power use 12V	RX IF Frequency: 1 MHz
6	Working current: max Less than 40 mA max, and min 9 mA	Low Power Consumption
7	Modulation mode: ASK	Easy For Application
8	Working frequency: 315MHz Or 433MHz	RX Operating Voltage : 5V
9	Transmission power:25mw 25mW (315MHz at 12v)	TX Frequency Range : 433.92 MHz
10	Frequency error: +150 kHz (max)	
11	Velocity : less than 10 Kbps	

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➢ IC HT12E and ICHT12D

HT12E is an encoder integrated circuit of 2^{12} series of encoders. They are paired with 2^{12} series of decoders for use in remote control system applications. It is mainly used in interfacing radio frequency circuits. The chosen pair of encoder/decoder should have the same number of addresses and data format. Simply put, HT12E converts the parallel inputs into serial output. It encodes the 12-bit parallel data into serial for transmission through an RF transmitter. HT12D is a decoder integrated circuit that belongs to 2^{12} series of decoders. These series of decoders are mainly used for remote control system applications, like burglar alarm, car door controller, security system e.t.c. It is mainly provided to interface RF circuits. They are paired with 2^{12} series of encoders. The chosen pair of encoder/decoder should have the same number of addresses and data format. HT12D converts the serial input into parallel outputs.

These devices are shown in Figure 2.1

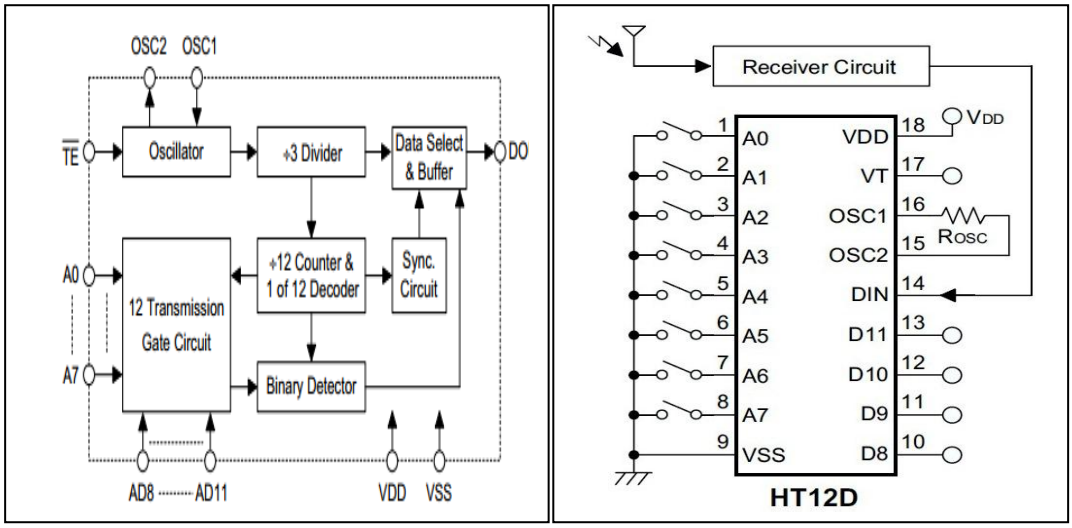

Figure 2.1.(a) Pin-diagram of IC HT12E; (b) Pin-diagram of HT12D

➢ IC 74174

These positive-edge triggered flip-flops use TTL circuitry to implement D-type flip-flop logic. They all have a direct clear input. Information at the D inputs meeting the setup and hold time requirements is transferred to the Q outputs on the positive-going edge of the clock pulse. Clock triggering occurs at a particular voltage level and is not directly related to the transition time of the positive-going pulse. When the clock input is at either the HIGH or LOW level, the D input signal has no effect at the output. It contains six flip-flops with single-rail outputs, and has buffered clock and direct clear inputs. There is an individual data input to each flip-flop. They are used as buffer/storage registers.

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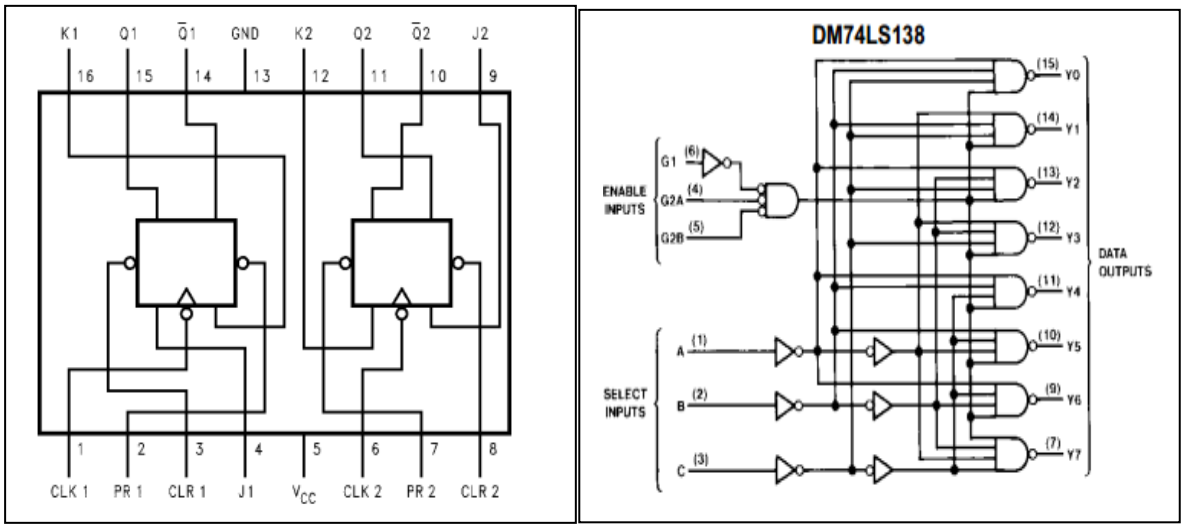

Figure 2.2.(a) Pin-diagram of IC 7476; (b) Pin-diagram of 74138/4013

These positive-edge triggered flip-flops utilize TTL circuitry to implement D-type flip-flop logic. All have a direct clear input. Information at the D inputs meeting the setup and hold time requirements is transferred to the Q outputs on the positive-going edge of the clock pulse. Clock triggering occurs at a particular voltage level and is not directly related to the transition time of the positive-going pulse.

- **Relay 12v, 10A**

This component is vital due to its feature as a high-quality single pole double throw (SPDT) sealed relay from Omron. They are used to switch high voltage, and/or high current devices. The load current is rated up to 10A, and it can be mounted directly into breadboard – 300mil spacing

- **Transistor BC548**

The BC548 shown in Figure 2.4 is a general purpose NPN bipolar junction transistor found commonly in European electronic equipment and present-day designs in Australian and British electronics magazines where a commonly-available low-cost NPN transistor is required. It is a part of a family of NPN and PNP epitaxial silicon transistors that include higher-quality variants, originating in 1966 when Philips introduced the metal-cased BC108 family of transistors which became the most used transistors in Australia and taken up by many European manufacturers. However, the BC546 and BC547 are essentially the same as the BC548 but selected with higher breakdown voltages while the BC549 is a low noise version, and the BC550is both high-voltage and low-noise. The BC548 is low cost and is available in most European Union and many other countries. It is often the first type of bipolar transistor hobbyist's encounter.

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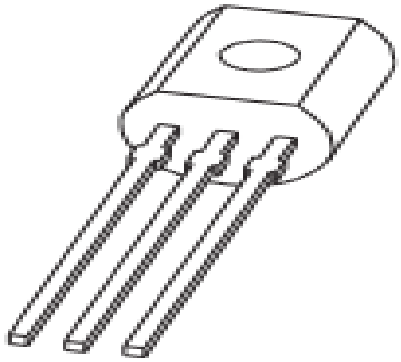

Figure 2.3.BC 548 NPN Transistor

- **Circuit Breaker**

A circuit breaker is an important component in this design. It works by an automatically operated electrical switch designed with the intention of protecting the electrical circuit from damage caused by overload or short circuit. Small circuit breakers may be manually operated, while larger units have solenoids to trip the mechanism, and electric motors to restore energy to the springs (Tom, 2004).

- **Push Button 4nos**

This device is a simple switch mechanism used for controlling some aspect of a machine or a process. These buttons are typically made out of hard material, usually plastic or metal. The surface is usually flat or shaped to accommodate the human finger or hand, so as to be easily depressed or pushed. The circuit diagram involving the corroboration of all these devices is shown in Figure 2.4

Operational Principle of Remote Control

The main sections of this multi-channel remote control circuit are the RF receiver and transmitter (433MHz transmitter and 433MHz receivers). By using this circuit, we can control 4 different phases, each of them independently by pressing the push buttons. When the button is pushed, a corresponding relay is turned ON and is turned OFF on the next push. Here, the relay load current is dependent on the relay used. In this research, a 12v, 10A operating relay was used. A serial encoder IC HT12E and a serial decoder IC HT12D were used, where the encoder IC encodes the parallel data to serial and decoder IC decodes the serial data to parallel during the wireless transmission. Furthermore, a 5v regulated power supply called a regulator for this circuit because ICs 7476 and 74138 is essential for its operation. The system has an appreciable advantage in that it does not require a ‘line of sight’. Compared to IR remote control systems, it also gives longer distance control (Figure 2.4).

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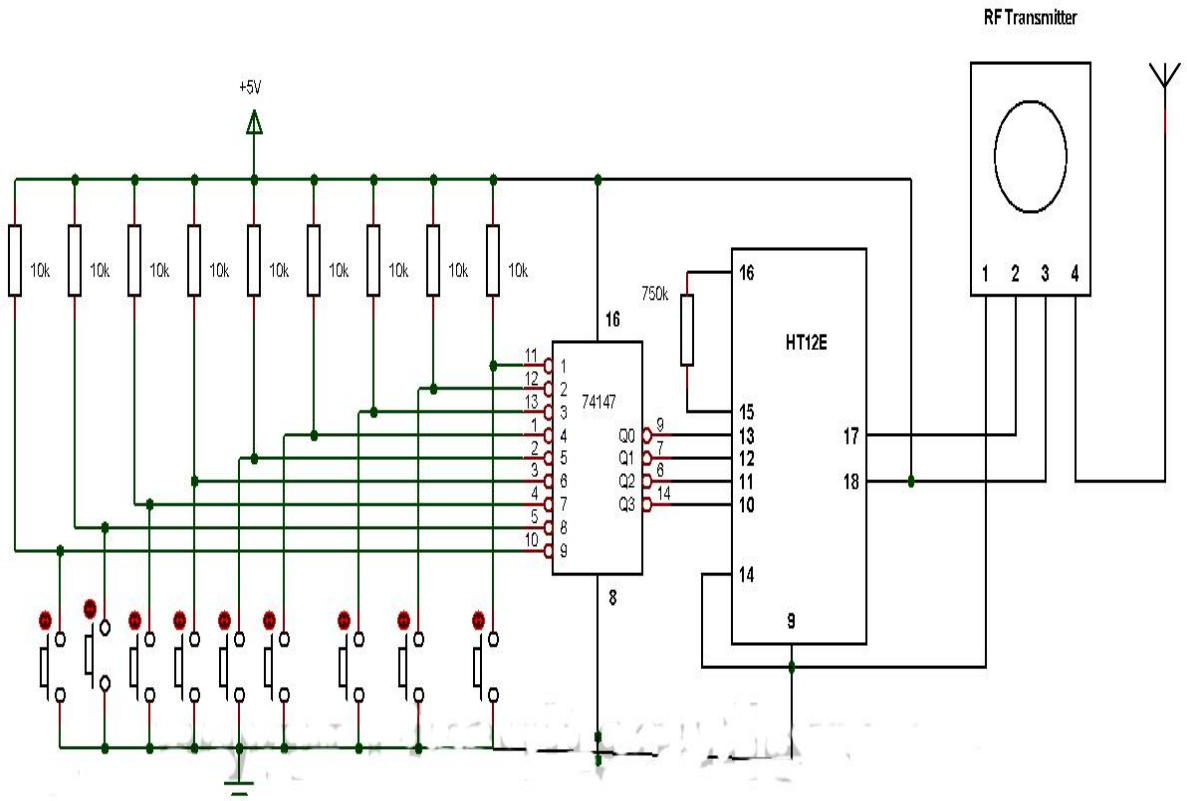

Figure 2.4.Radio Frequency Transmitter

Operational Principle of Relay

The flow of power through the INPUT results in the activation ofan electromagnet, generating a magnetic field that attracts a contact and activates the second circuit (LOAD). When the power is switched off, a spring pulls the contact back up to its original position, switching the second circuit off again. This is an instance for a "normally open" (NO) relay. The contacts in the second circuit are not connected by default. They switch on only when current flows through the magnet. Other relays are "normally closed" (NC; the contacts are connected so that current flows through them by default) and switch off only when the magnet is activated, pulling or pushing the contacts apart. Normally open relays are the most common.

The activation of this circuit supplies current to the electromagnet that pulls a metal switch closed and activates the second (output circuit). When small current flows in the input circuit, it activates the electromagnet which produces a magnetic field all around it. The energized electromagnet pulls the metal bar in the output circuit towards it, closing the switch and allowing a much bigger current to flow through the output circuit. The output circuit operates a high-current appliance such as a lamp or an electric motor. Furthermore, relatively small current in the input circuit thus, activates the larger current in the output circuit. The input circuit is switched off and no current flows through it until something (either a sensor or a switch closing) turns it on. The output circuit is also switched off.

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Operational Principle of Distribution Box

The application of a distribution box to distribute either single or three phase supplies is a function of the installation specifics. Although, distribution board equipment, layouts, and legislative requirements differ from country to country, the basic principles of "distributing" a single supply to various individual points while ensuring that safety and control for each remains the same. They mostly consist of a panel or enclosure supplied with a single incoming electrical feed cable. The power is then split among several small circuit breakers or, in the case of older boards, fuses which in turn feed power to different consumption points or circuits.

Most distribution boards feature a single incoming supply cable feeding multi- or single-phase power to the board. The live feed from this cable is generally first connected to a main breaker, fuse, or residual current detector (RCD). These components allow the whole board to be isolated for repairs in the case of a main breaker or fuse while the RCD protects against ground fault shock and fire hazards. In the case of a single-phase supply, the live feed is taken from the main breaker or RCD and bridged across the top of a series of individual fuses or mini circuit breakers. Multiphase supplies typically have several circuit breakers for each phase and with each group bridged along their incoming terminals. The neutral and earth cores of the supply cable are then connected to separate bus way bars.

Cables from the individual power outlets, light circuits, or machine points are then inserted into the distribution board on the opposite side of the supply cable. The live leads from each cable are connected to suitably rated circuit breakers and the neutral and ground leads to the appropriate bus way bars. This creates a distribution environment where each circuit is fed by a suitable circuit breaker and may be isolated if the need arises without disrupting the rest of the supply.

Method of Operation of Automatic Change Over

The design and construction of A.C voltage monitoring and control circuit was achieved by using voltage monitoring relay (VMR) as a primary component of the power sensing and control circuit, which was used for measuring and comparing the voltage level of the utility supply with a set voltage tolerance range (185-250V A.C).In addition to this, a 12A miniature circuit breaker acted as a switch to the power supply from the public utility end of the ATS. Both power switching circuit and Display unit was designed. ABB-type power contactors rated 12A, 220V A.C, timer relays to provide some delays (5 seconds) during the starting of the generator and transfer of the connected load vice versa from the both power sources depending on the side with steady electrical power at any point in time are used. The switching mechanism of the generator is done with a 12V D.C supply battery and auxiliary contacts of the timer relays and the contactor. The automatic ignition and stopping of the generator depends on whether the contactors are energized and DE energized. The digital multi meter (DMM) displaying the output voltage and the rated current of the ATS have a

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12V and 5V D.C power supply unit (PSU), a current transformer (C.T), an ADC microcontroller to convert the measured analogue A.C voltage and current.

Results and Discussion

Automatic Change Over

When the mains power supply is present for the power input of the automatic change over, the changeover disconnects the power output supply of the generator by giving out the regular mains power input as its final output power supply. The second operation is the triggering OFF of the generator until when mains power has a power failure.

In the absence of mains power, the changeover contractor is normally connected in the relay operation. When PHCN produces input, the relay at the changeover performs a switch which will produce a load current from PHCN input. This input is always fixed and connected to the generator input. The generator supply is always fixed to the normal connect section of the relay while the mains supply is always fixed to the normal open section. Various tests were carried out on this project which includes relay switching test (this is done to be sure the relays can switch back to generator when the power is out and vice versa), generator starting test and voltage variation test (this is done to be sure that the output voltage is within permissible limit which is between 195V and 245V) and the testing of the entire automatic changeover switch. However, the timer relays provide delay of 5 seconds during the starting of the generator and transfer of the connected load and vice versa.

Operation of a Relay

A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current. The heart of a relay is an electromagnet (a coil of wire that becomes a temporary magnet when electricity flows through it). The relay acts as a kind of electric lever: switch it on with a little current of 5v used in this project and it switches on ("leverages") another appliance using a much bigger current as in the case of the distribution box. Many sensors are incredibly *sensitive* pieces of electronic equipment and produce only small electric currents. But often we need them to drive bigger pieces of apparatus that use bigger currents. Relays bridge the gap, making it possible for small currents to activate larger ones. That means relays can work either as switches (turning phases or appliances on and off) or as amplifiers (converting small currents into larger ones).

Results of the Distribution Box

The Figure 3.1 shows the picture of the distribution box and automatic change over relay. This project distribution board works in a 4-channel way single phase. Any overloading of any of the channels will induce a short time which results in a breakup of the circuit breaker or fuse. The surge of the distribution board will also result to the cut out of the circuit breaker. The short circuit of any of the phases will also result in an open circuit of the

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breaker. Earth leakage is also protected in such a way that when the fault occurs, the breaker will open as a result of the excess current passage to the ground.

From the external circuit, the project distribution box is constructed to work with a single-phase system. In a case in which it is connected to a 3-phase external circuitry, a cut out is needed to select a single phase to be combined with the distribution box. The project distribution box is an automatic distribution box controlled by a radio frequency remote-control system using a 433MHz transmitter and a 433MHz receiver with a relay operating with an operating voltage of 5v supplied by an internal power regulator and a transistor operating as a switch.

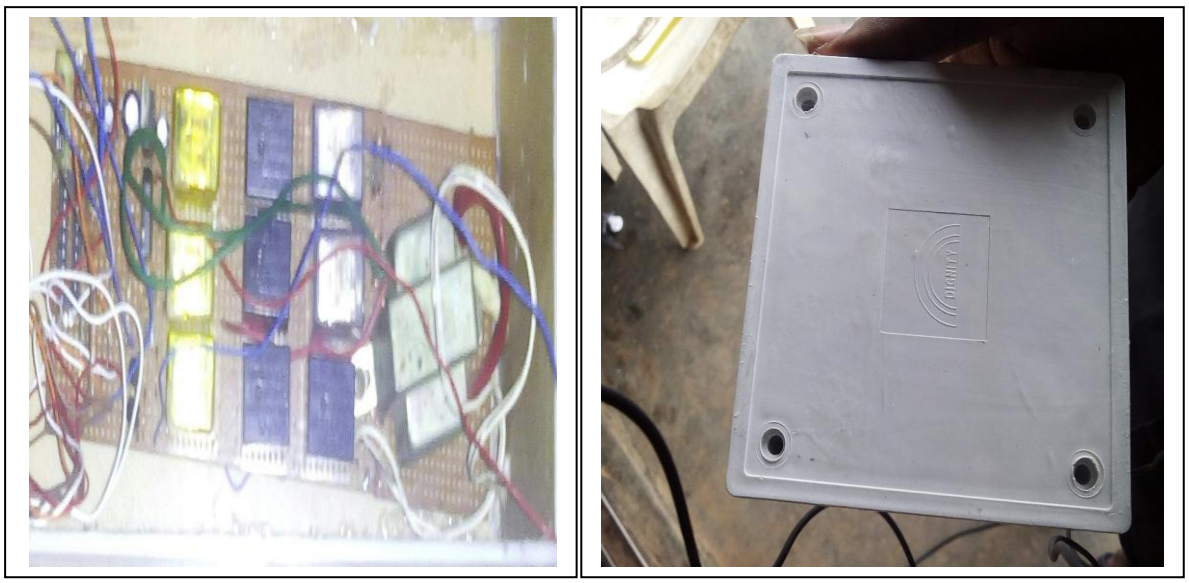

Figure 3.1.Distribution box and automatic change over relay

In the distribution box, remote control employed in the embodiment of the present invention comprises a connecting electrical equipment into the line input and a control switch, analog

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data acquisition device connected to the control switch and connect the analog signal acquisition device limit. The resulting output of the signal processing apparatus further comprises a signal processing means connected to the wireless transmission module, wherein, the wireless transmission apparatus to the signal processing module receives the result of the processing of the analog signal acquisition parameter information by means of the electrical equipment will be collected will be treated transmitted to remote monitoring equipment, so remotely located monitoring equipment maintenance personnel to perform timely maintenance of the distribution box [7].

Result of the Remote Control

Each button of the remote control of the 4channels of the remote control were connected in series each with a 10K resistor and connected to an IC 74147 and IC HT12E which serves as an encoder of the desired command signal prompting to be sent by the 433MHz transmitted. The system is grounded so as to have a complete circuit. As the button is pushed to turn on, it energizes the designated relay attached to that phase number on the distribution box, and as the same button number is pushed again for turn off, the relay removes from contact and it turns off. There not allowing current flow in through that phase as such could be repeated for the different wanted phase. A house with 12 rooms using distribution box can apply a phase for 2 rooms thereby providing an increased rate of control over the usage of current in each room and in the case where there is an outbreak of fire.

Conclusion

In summary, this research was able to develop the construction of change-over and distribution box using automation systems. This system serves an alternative purpose for the conventional manual techniques hence, stability and switching of electrical power supply between two sources of electrical power becomes feasible. The cost-effective remote control was designed with 433 MHz module, a battery and push buttons. In addition, the IC'S offers exceptional performance with its advanced RF features, including automatic antenna tuning to guarantee maximum transmit distance on every button press.

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