DESIGN OF AN ARDUINO BASED RFID LINE SWITCHING USING SOLID STATE RELAY WITH INDIVIDUAL PHASE SELECTION

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ABSTRACT

The use of line switching in the power system cannot be over emphasized. When fault is detected on a distribution line, the line is disconnected/isolated due to the presence of this fault and switched over to another distribution line by a line switching system. In this paper, a simple and reliable line switching system for distribution lines is presented so as to achieve the basic objectives of power system protection which are continuity of power supply and safety of personnel and equipment. The design includes the utilization of numerous modules/units such as the radio frequency module (RF module), a microcontroller, and a Radio Frequency Identifier (RFID) reader. The RFID card is swiped across the sensor and the experimental result shows the phase selected and the output of phase(s) available upon selection.

Keywords: *Line switching, distribution line, power system protection, RFID, SSR*

1   INTRODUCTION

Line switching is used to connect and disconnect distribution substations to and from a distribution grid. At the cradle of technology, several faults were associated with line switching, which were achieved using manual switches or fuses. It has endangered lives due to its exposure leading to electrocution during maintenance, thereby compromising the objective of power system protection. With advancement in technology and for realization of the objectives of power system protection, that is, continuity of supply and safety of both personnel and equipment; (Gupta *et al*., 2009) the need to avert these faults was of paramount importance. This brought about the development of automated line switching using relays and contactors. As time progresses, the relays and contactors begin to fail due to damage encountered (wearing of contacts) as a result of arcing and under voltage. In electrical power system, prior to the load in substations are the feeder pillars. Feeder pillars; which are distribution transformer cabinet boards, are used by the power authority for supplying 3-phase and single-phase loads to feed residential and some small scale commercial consumers. This is done at distribution level of 415 V and 240 V respectively which is a safe, economical and convenient way for operational and maintenance purposes. The use of fuses within the system is of paramount importance. To avoid overloading and ensuring the safety of lives and equipment from faults such as short circuit (arcing); fuses, which are overcurrent protective devices with a circuit opening fusible part are used. These fuses can become heated and severed by the passage of large amount of current through it. Before the advent of modern technologies; when faults occur, fuses are disconnected using insulated pliers so as to create a safe ground for repairs or maintenance. Also, electricity consumer may experience intentionally engineered rolling black out due to fault or maintenance. Even with that, this method still exposes the operator or technologist to the risk of being electrocuted (Michael *et al*., 2010).

In recent technologies, automated switching of lines using Radio Frequency Identification (RFID) and Solid State Relays (SSR) have been introduced (Ahmed *et al*., 2009). In this design, an Arduino Based Radio Frequency Identification (RFID) Line Switching using Solid State Relay (SSR) with Individual Phase Selection is presented. This paper is focused on achieving the objectives of power system protection by ensuring safety of lives and continuity of power supply through selection of phases and the use of SSR.

2   REVIEW OF RELATED WORKS

(Filipovic-Grcic *et al*., 2017). Presented the application of controlled switching techniques for limitation of switching over voltages (SOVs) and transient currents on 400 kV transmission line with capacitive voltage transformers installed at both ends. The work shows that the controlled switching significantly reduces SOVs, current transients and energy stress of station surge arrestors. The controlled switching is a method for eliminating harmful transients via time-controlled switching operations. Consequently, the controlled switching reduces the mechanical and electromagnetic stresses of the high voltage equipment and also prevents the unwanted operation of relay operation. This work has to do with clearing of transient faults for improving continuity of power supply. It is thus limited to high voltages and applicable to transmission lines. (Huang *et al*., 2014). Investigates the stability issues that might arise when incorporating transmission line switching into smart grid planning and operation. To demonstrate the

feasibility of line switching, scenarios and dynamic simulations were used to demonstrate system security margin and online stability issues. Results shows that proper line switching can resolve system energy and boost system security margin, even though less transmission lines were used. It also reveals that small signal instability can be triggered by line switching. This work was employed in transmission lines for system stability. The author did not consider line switching in distribution system. (Tada & Kitamori, 1996) introduces an object of the present invention to provide a line switching system for switching lines by using Automatic Protection Switch (APS) byte. It entails line disconnection between the nodes when a fault is found in the transmission devices of the nodes to switch one transmission path to the other transmission path. With this system, there is no need to be conscious of the state for setting the lines of the entire system. Thus, it becomes possible to reduce the time required for switching and the amount of managing data. (Michael *et al.*, 2010). presents Arduino based Radio Frequency Identification (RFID) Line Switching using Solid State Relay (SSR). In this work, no individual phase selection. Intentionally engineering rolling black out is encouraged as the healthy phase(s) is not separated from the faulty phase (s), instead all lines are either switched to logic 0V (off) or to logic high (5V). During maintenance or clearing of faults, all phases are taken out of supply irrespective of whether faulty or not, hence the objective of power system protection cannot be realized as continuity of power supply is compromised. The application of RFID in power system by different researchers can also be seen in works presented by (Ralph and Mackenzie, 2014, Yerlan and Alex, 2014)

3 METHODOLOGY

Line switching is used to connect and disconnect distribution substations to and from a distribution grid. This section of the paper contains the processes involved to get the system working. This section mainly deals with the designed aspect of the hardware and the analysis of individual unit that made up the device. Figure 1 shows a block representation of an Arduino Based RFID Line Switching Using Solid State Relay with Individual Phase Selection.

3.1.1 AC TO DC CONVERTER UNIT

This is achieved via the use of a 12V step down transformer TR1 as shown in Figure 2. The main supply is step down from 220V to 12VAC. This is then converted to DC via the bridge rectifier BR1. The DC power produced still has some elements of AC which is then filtered off via the use of capacitor C1. Afterwards, voltage regulators of 9V and 5V are used since 9V is used

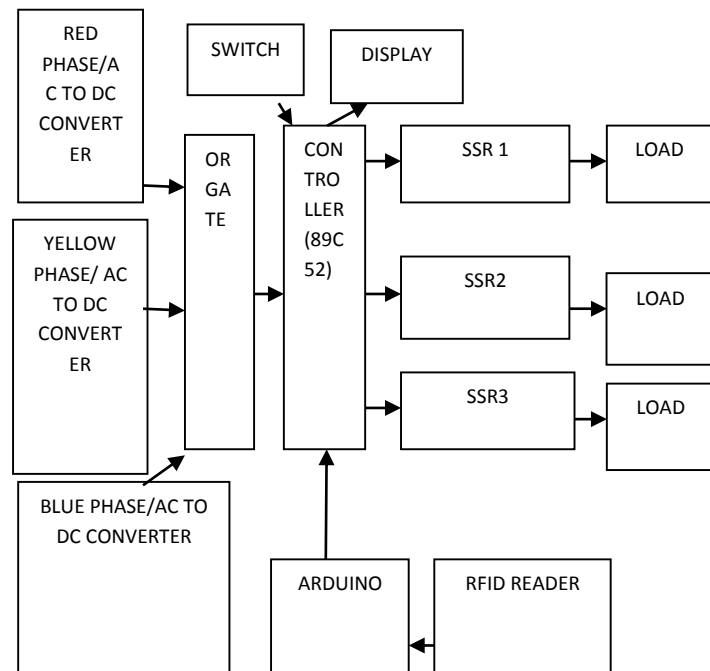to power the Arduino board while the 89C52 is powered with 5V.

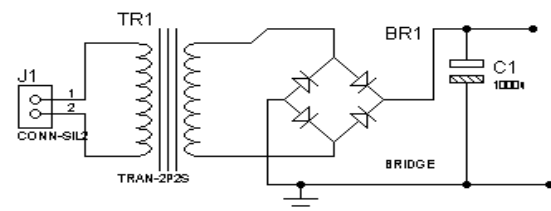Figure 1: Block diagram of the system

Figure 2: Circuit diagram of the power circuit

3.1.2 OR Gate Unit

The use of the OR Gate is to ensure that power is supplied to the controller whenever power is detected either before or after the fuses. To achieve this, diodes D1, D2 and D3 was used as shown in the Figure 3. Figure 4 Shows the three phase AC to DC converter with voltage regulators.
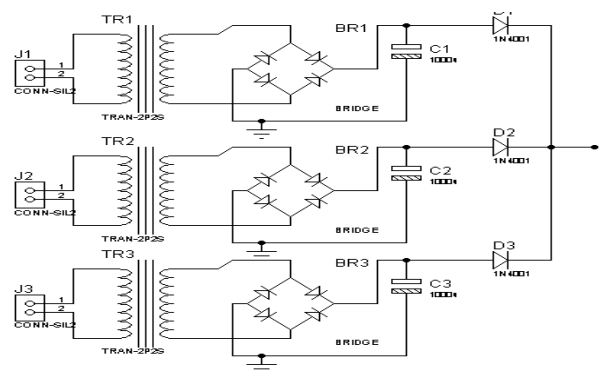

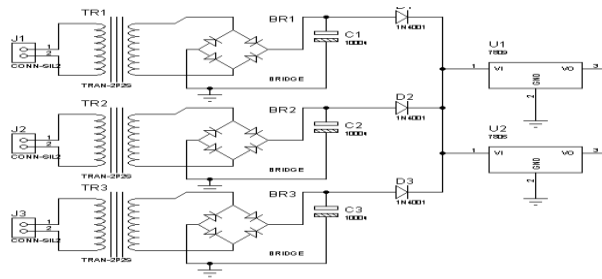Figure 3: The circuit diagram of AC to DC Converter with Diodes as OR gate.

Figure 4: Circuit diagram of the three-phase supply with voltage regulator.

3.1.3   Controller Unit

The controller used for selection of the phases is 89C52. The controller was clocked with 12MHz crystal at pin 18 and 19. Also, pin 40 and pin 31 are connected to 5V while pin 20 is grounded. This will aid the system to be powered and enabled so as to fetch instructions from within its memory. Pin 9 is connected to 5V supply via a 1µf capacitor. The circuit is shown in Figure 5.

3.1.4   Display Unit

This section was achieved by the use of a liquid crystal display (LCD). Instructions from the datasheet are employed in interfacing the LCD with the controller. The different control signals that could initialize the system were specified. All these instructions were adhered to for success in the prototype made (Abubakar et al, 2018). The symbolic representation of the device is shown in Figure 6.
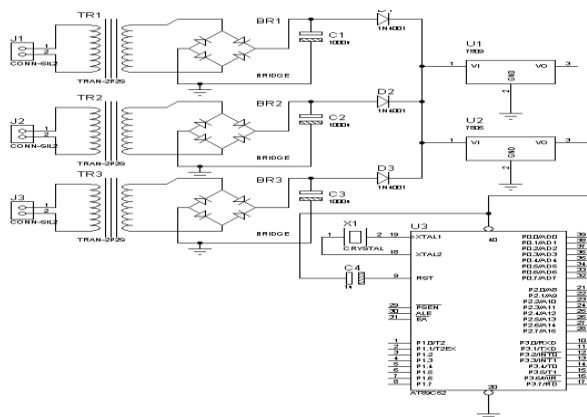

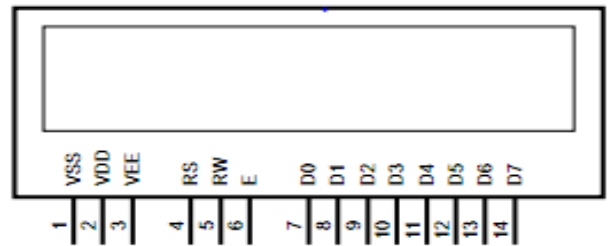Figure 5: Circuit diagram of the controller connected to the power supply

Figure 6: Symbolic Representation of the LCD (Abubakar *et al*., 2017)
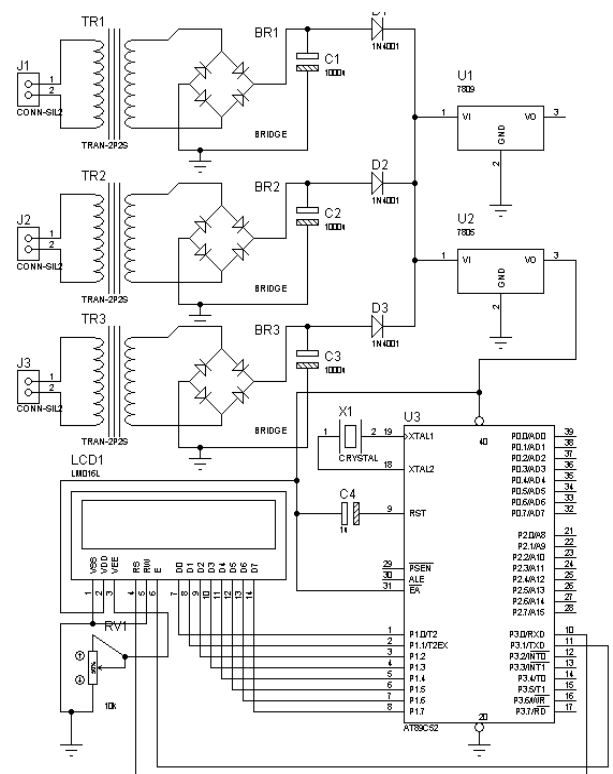

Figure 7: Circuit diagram of the LCD interfaced with the circuit.

3.1.5   Switches Unit

The button was introduced to ensure the selection of active lines. The momentary switches called buttons are connected in series with 1kohms resistor as shown in the Figure 8. Closing the switch will aid the output of 0V which is logic low while if opened it outputs logic high.
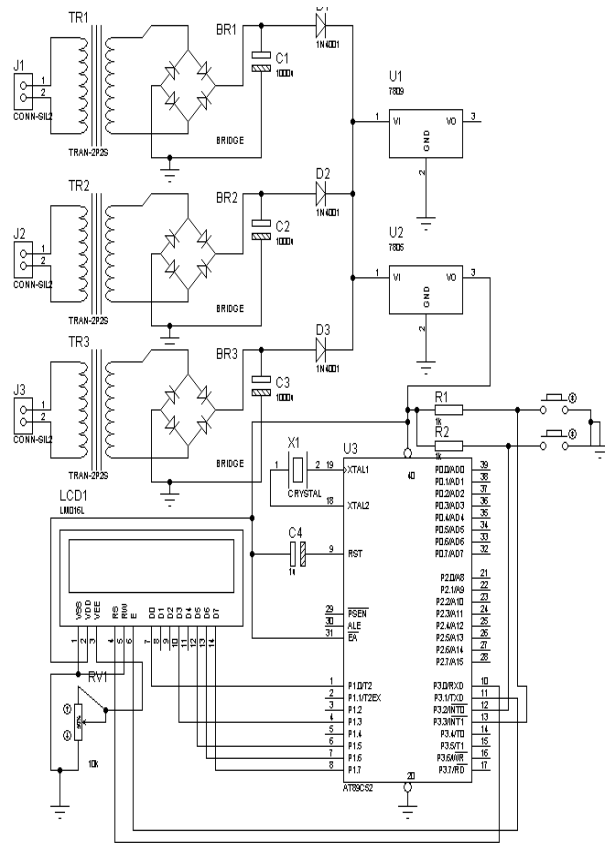
Figure 8: Circuit description of the system and buttons added.

3.1.6   Arduino Unit

The Arduino used as shown in Figure 9 is Arduino Uno R3. The micro controller board is made with ATMEGA328 which has 14 digital input and output pins, 6 analog inputs, 16MHz ceramic resonator, USB connector and many more. However, because of the different modules within it, this controller was chosen to reduce cost and time of design. The controller serves as the central processing unit of the whole design. It is interfaced RFID Reader and the 89C52. Figure 11 shows the device in the whole circuit.

3.1.7   RFID Sensor Unit

The sensor as shown in Figure 1., used in this work is a Mafare product MFRC522. The 3V driven sensor comes with a card (RFID tag). This card is embedded with some information which is picked up by the sensor at proximity and then interpreted by the controller.

Figure 9: Pictorial view of Arduino Uno R3

Figure 10: Pictorial view of the RFID sensor

3.1.8   Solid State Relay Unit

This is an opto-coupler made up of a light emitting diode and a photo triac. For the triac to allow AC power to flow through, the LED has to be ON. This is achieved when the controller sends Logic 1 (5V) to a resistor R1 connected in series with the LED. However, in this project, three SSR were used for switching the three phases.

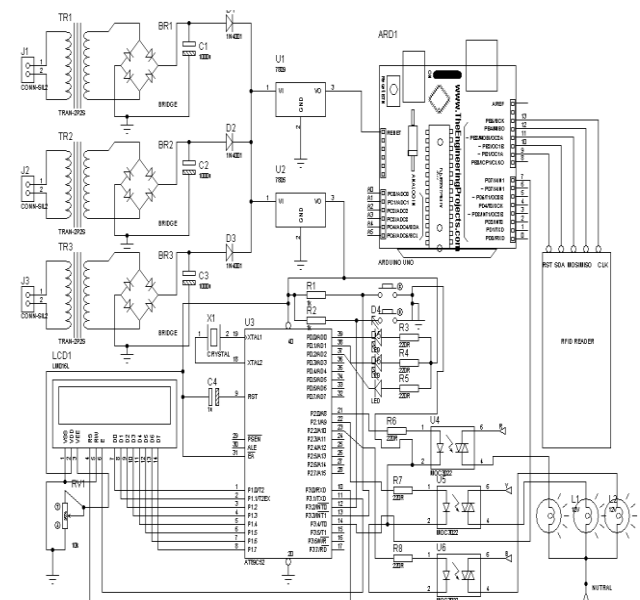The circuit diagram in Figure 11 shows the connection of the different circuit of the entire design.

Figure11: Complete circuit diagram

4 RESULTS

The design was tested and the following results were obtained as shown in tables 4.1,4.2 and 4.3. Table 4.1 shows the experimental result of the phase selected and output of phase(s) available upon selection. Table 4.3 shows the lamp that comes on which is in phase with the line selected from the output obtained in Table 4.2. The lamps come on only after swiping the RFID card on the sensor.

TABLE 4.1: EXPERIMENTAL RESULT OF THE POWER CIRCUIT

S/N	Power IN Red Phase	Power IN Yellow Phase	Power IN Blue Phase	Power OUT
1.	0	0	0	0
2.	0	0	1	1
3.	0	1	0	1
4.	0	1	1	1
5.	1	0	0	1
6.	1	0	1	1
7.	1	1	0	1
8.	1	1	1	0

Key; Power Out=1 when 12V is measured and Power Out=0 when 0V is measured.

4.1 DISCUSSION OF RESULTS

Table 4.1 shows that the main circuit is powered whenever any of the phases is available by giving an output voltage of 12 V for phase availability and 0 V for non-availability of phase; The OR Gate is used to ensure that power is supplied to the controller whenever power is detected in any of the phases. Table 4.2 shows the phase(s) available upon selection by giving a numeric value 1 when the phase is selected and 0 when the phase is non selected. Table 4.3 shows the effect of the phase(s) selected on the lamp(s) when the RFID Card was swiped across the sensor. The lamp(s) turns on when it corresponds with the phase(s) selected and the lamp(s) turns off when the phase(s) is/are not selected only after the RFID Card has being swiped on the sensor by giving numeric value 0 when the lamp is off and 1 when the lamp is on.

5 CONCLUSION AND FUTURE WORK

The results obtained showed that the Arduino Based RFID line Switching Using SSR with Individual Phase Selection is capable of not only connecting and disconnecting distribution lines to and from a distribution substation but also capable of selecting the phase(s) at which to connect or disconnect. For future research purposes, the following recommendations should be put into consideration:
1. A database should be built with the system so as capture the identity of the operating personnel;
2. More intelligence features should be incorporated in the system.

TABLE 4.2: EXPERIMENTAL RESULT OF PHASE SELECTION AND OUTPUT

S/N	Red Phase	Yellow Phase	Blue Phase	OUT
1.	0	0	0	NIL
2.	0	0	1	Blue Phase
3.	0	1	0	Yellow Phase
4.	0	1	1	Yellow & Blue Phase
5.	1	0	0	Red Phase
6.	1	0	1	Red & Blue Phase
7.	1	1	0	Red & Yellow Phase
8.	1	1	1	ALL

Key: 1=Selected   0=Not selected

Plate I: Result showing connection to power supply

Plate II: Result showing initialization

TABLE 4.3: EXPERIMENTAL CONTROL OF THE RFID
CONTROL OF THE PHASES

S/N	L1	L2	L3	OUT
1.	0	0	0	NIL
2.	0	0	1	Blue Phase
3.	0	1	0	Yellow Phase
4.	0	1	1	Yellow & Blue Phase
5.	1	0	0	Red Phase
6.	1	0	1	Red & Blue Phase
7.	1	1	0	Red & Yellow Phase
8.	1	1	1	ALL

Key: L1=Lamp 1, L2=Lamp 2, L3=Lamp 3
0= When lamp comes off
1= When lamp comes on.

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