Implementation of a Microcontroler Based Multiple Source Power Supply Selector with Priority Option

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Increasing global use of technology in everyday chores has raised the need for electric power in our lives the need for constant power thereby becomes very paramount for the smooth running of modern systems. In Nigeria incessant outages have led to failures in systems and sometimes lives, necessitating the use of multiple sources of power for homes, offices and industries, each of which costs differently to use. This work presents the design and implementation of a microcontroller based multiple source power selector with priority selector. The inclusion of priority selection means each source can be selected for use based on its cost or quality/availability. When cost is prioritized by selection then mains power is first selected for use before generator, and when both are absent then solar is optionally available for selection. When uninterruptible power (UP) is prioritized then the source with better quality is selected for use. The three sources are each stepped down using three separate step down transformers, The output of which are rectified and sampled to an ATmega328 microcontroller which is programmed using C++ language to select the most appropriate output based on the Cost or quality/availability, the microcontroller commands relays that perform the switching action i.e. connecting the load to the most appropriate source. The

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system was simulated in Proteus simulation environment, Simulation result show that in all cases of performance the source that is supplied to the output is based on the priority mode selected. This system can be used in economy mode for homes where cost of power is the criteria while in hospitals the UP-priority mode is recommended because availability is what matters. This device reduces the possibility of complete power outage in the event of a power failure in any specific source. Users can connect their electronic gadgets to the device, which reduces the response time needed to switch from one power source to another.

1. INTRODUCTION

Electric power supply in Nigeria and many other developing countries is highly unstable [1], causing significant negative impacts on both consumers and the equipment they rely on for electricity [2]. Power instability, phase failure, and other technical issues pose a severe threat to economic development in these regions [3,4]. Unfortunately, most businesses - industrial, commercial, and residential - depend on public power supply, which is often erratic and unreliable [5]. This dependence makes it challenging to safeguard appliances and equipment from the effects of inconsistent power supply, necessitating the automation of phase change during phase failure or total power failure [6]. In most cases, many companies, be it domestic or industrial, now employ more than one source of power, namely solar, generator and mains. The availability of the three sources means that any can be selected for use. For ATMs, Surgery, zoom meetings, online classes, etc. uninterruptible power is needed, while for casual entertainment like watching television, listening to music, etc. the cheapest source is sufficient even if it is erratic. In the past changeover is manually done meaning that much time and effort would be required in the process of manual change over [7,2]. The delay in the process needed for the source change may cause serious damages to machines and even the products, may even cost life in surgical cases, hence, there is need for automatic source switching system with priority selection option [8-10]. Additionally, in situations where a single-phase public utility prepaid meter is operated with a single-phase power supply unit and there is phase failure from the public utility power supply, the prepaid meter will stop reading. In such cases, someone needs to be present always to make the changes at any point in time. However, automatic systems can be used to overcome these challenges.

2. METHOD OF DESIGN

In actualizing this system, the block diagram of Figs. 1 and 2 was employed as a guide for the calculation and or selection of components values.

2.1 Voltage Sampler Design

Each of the source's 220V is converted to 12V using a 220V/12V stepped down transformer [11], the output of which is rectified and filtered to be used by the microcontroller as sample voltage. The connection for sampling is shown in Fig. 2.

The voltage sampler or source is designed with the following specifications: Output voltage 12V ± 5 % at 0.5A with maximum ripple voltage of 2V peak-peak.

Choice of rectifier:

A bridge rectifier made from four diodes all 1N4001 is chosen, data sheet says it has a forward voltage drop of 1.0V at 1A

Choice of transformer voltage:

Vrms * 1.414 must be > 12 + 1.0 + (Vripple = 2V) = 15.0v

With Vrms = 15.0/1.414
= 10.6V

The nearest suitable transformer is 220V at 1.0A Transformer power = I*V [12]

P=220V*1.0A
=220W

Choose of the smoothing capacitor:

To determine the capacitor size

Vpk-pk ripple= Iload / fC   or   C = Iload / f * Vpk-pk ripple [11]

C = 0.5 / 100 * 2

= 0.5/ 200

= 0.00025f

= 250 μf with a minimum voltage rating of 15V + 20% safety margin = 18.0V

2.2 The Circuit Diagram

The completed designed circuit diagram is given in Fig. 3.

2.3 Microcontroller/Programming

The microcontroller employed in this design is an Arduino nano microcontroller. This controller comprises of an ATMEGA328p chip. The Arduino program was written in C++ language, compiled by the Arduino IDE windows program and uploaded into the chip via USB connection.

The flow chart for the logic flow in the program is given in Fig. 4.

2.4 Method of Simulation

The designed circuit was drawn in proteus 8.0 software in windows 10 platform. Simulation was done under two different settings as tabulated in Table 1 and Table 2. The following scenarios were part of the simulation.

Scenario 1: Simulation showing mode selection

Scenario 2: Simulation showing output as mains under economy mode when all three sources are available

Scenario 3: Simulation showing output as solar under UPS mode when all three sources are available

Scenario 4: Simulation showing output as gen under UPS mode when all only solar and mains are available.

3. RESULTS AND DISCUSSION

The results of the simulations were summarized and presented in Table 1 and Table 2.

From the simulations, it can be observed that whenever a mode is selected, it influences the selection of a source based on criteria earlier stated.

From result Table 1, when economy mode is selected, it can be observed that mains is selected in all conditions as long as it is present because mains is the cheapest source of electricity in Nigeria. Generator is selected whenever mains is absent due to the fact that generator is the next cheapest source of power. Solar being the most expensive is only selected whenever the other two sources are absent [13,14].
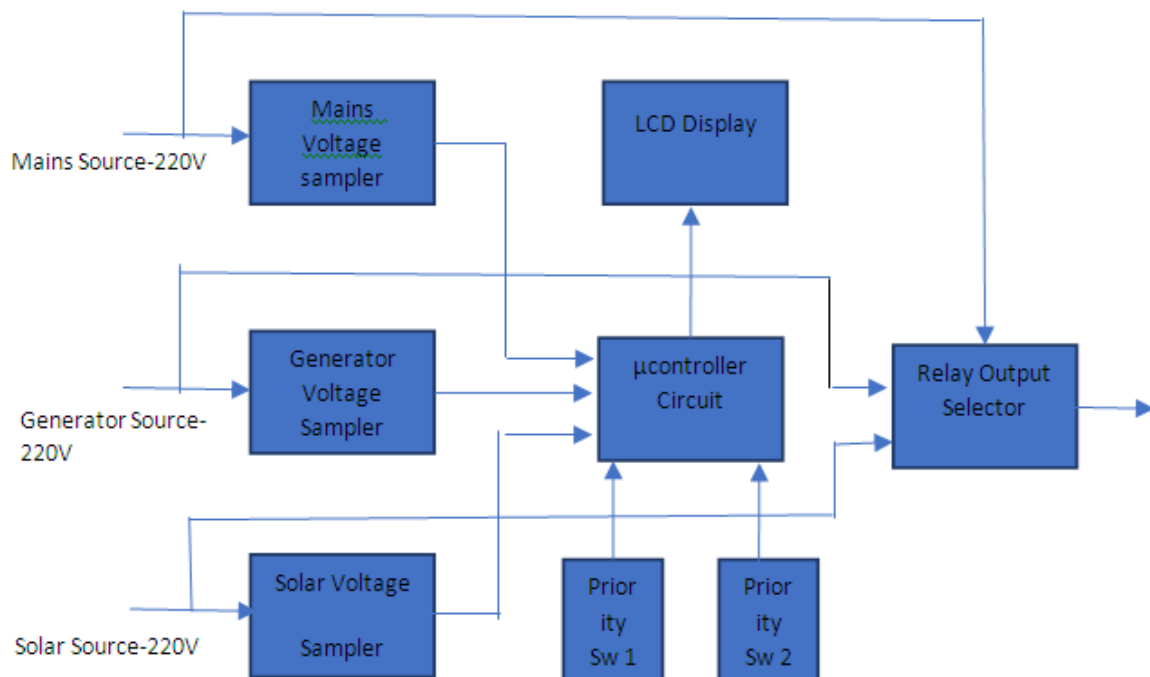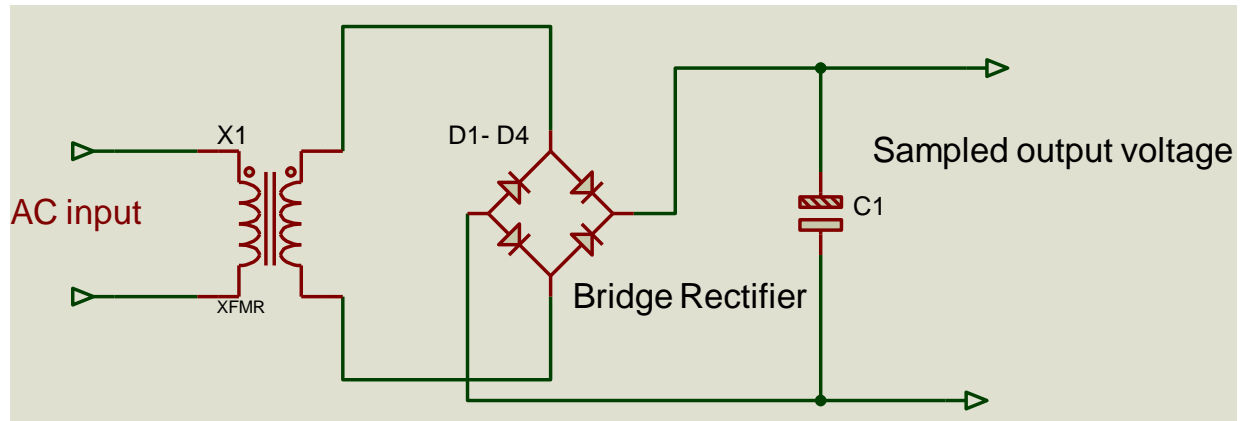

Fig. 1. Block diagram of the multiple source power selector
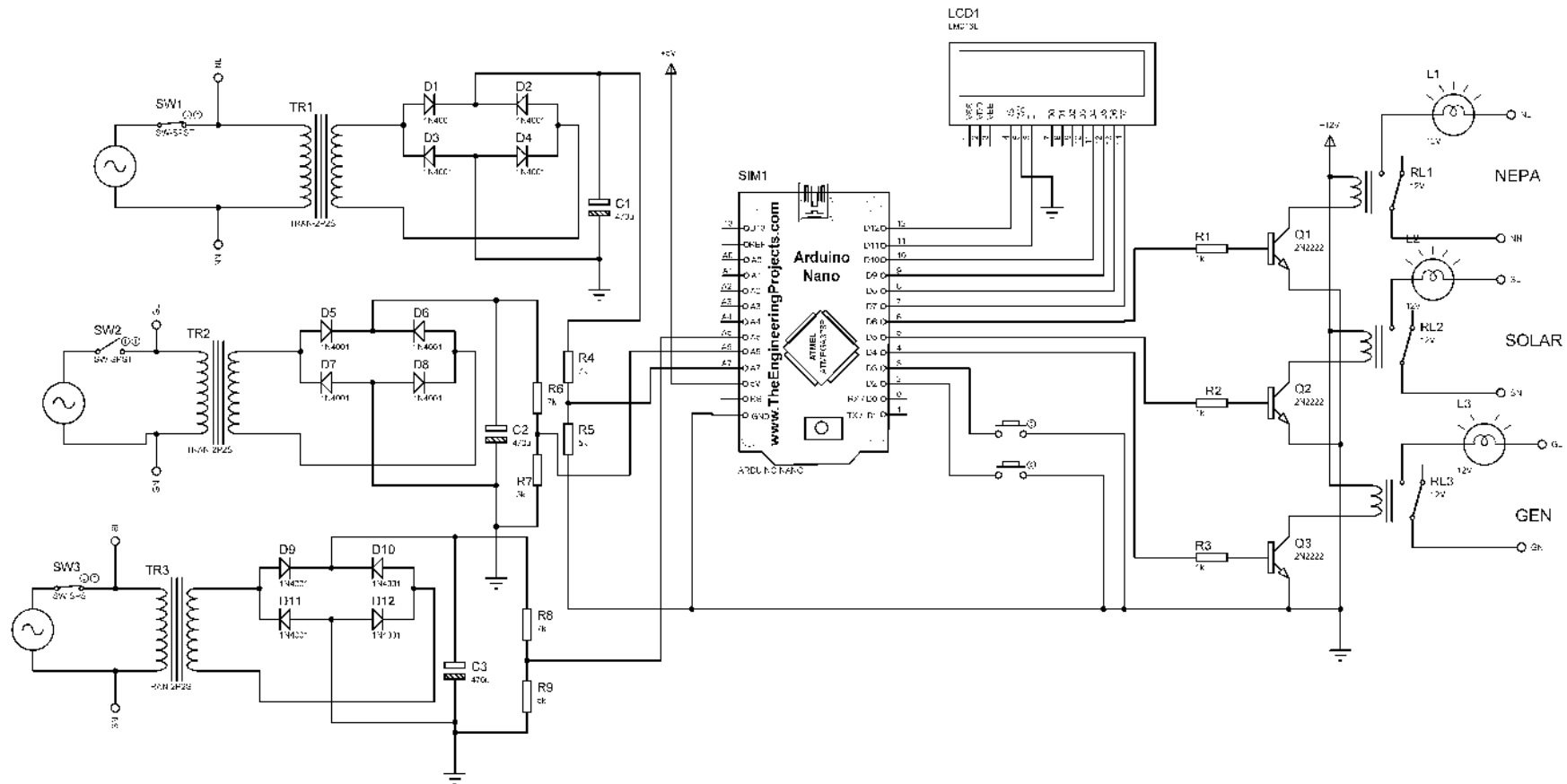
Fig. 2. The sampling unit

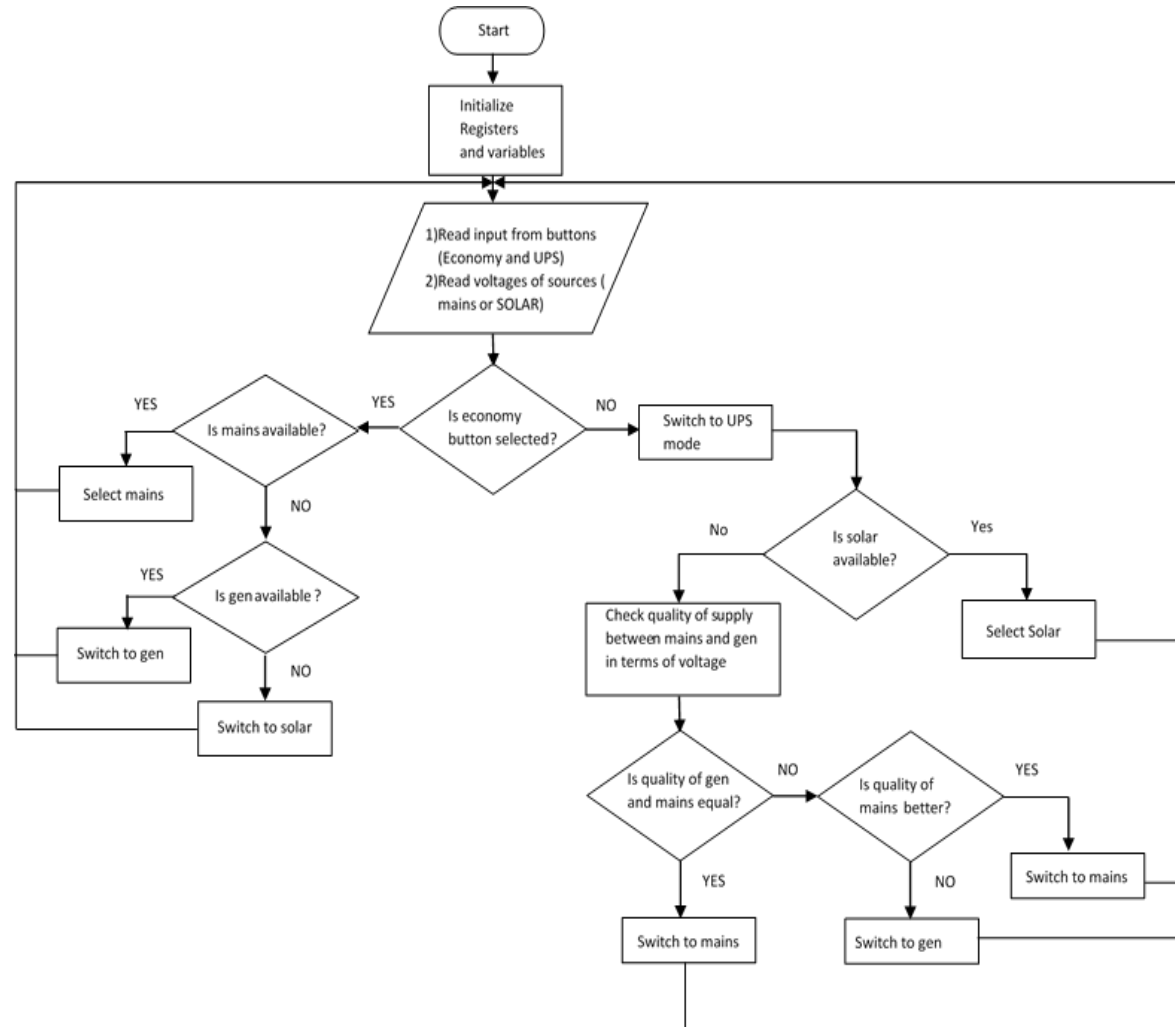**Fig. 3. The circuit diagram of the multiple power source selector**
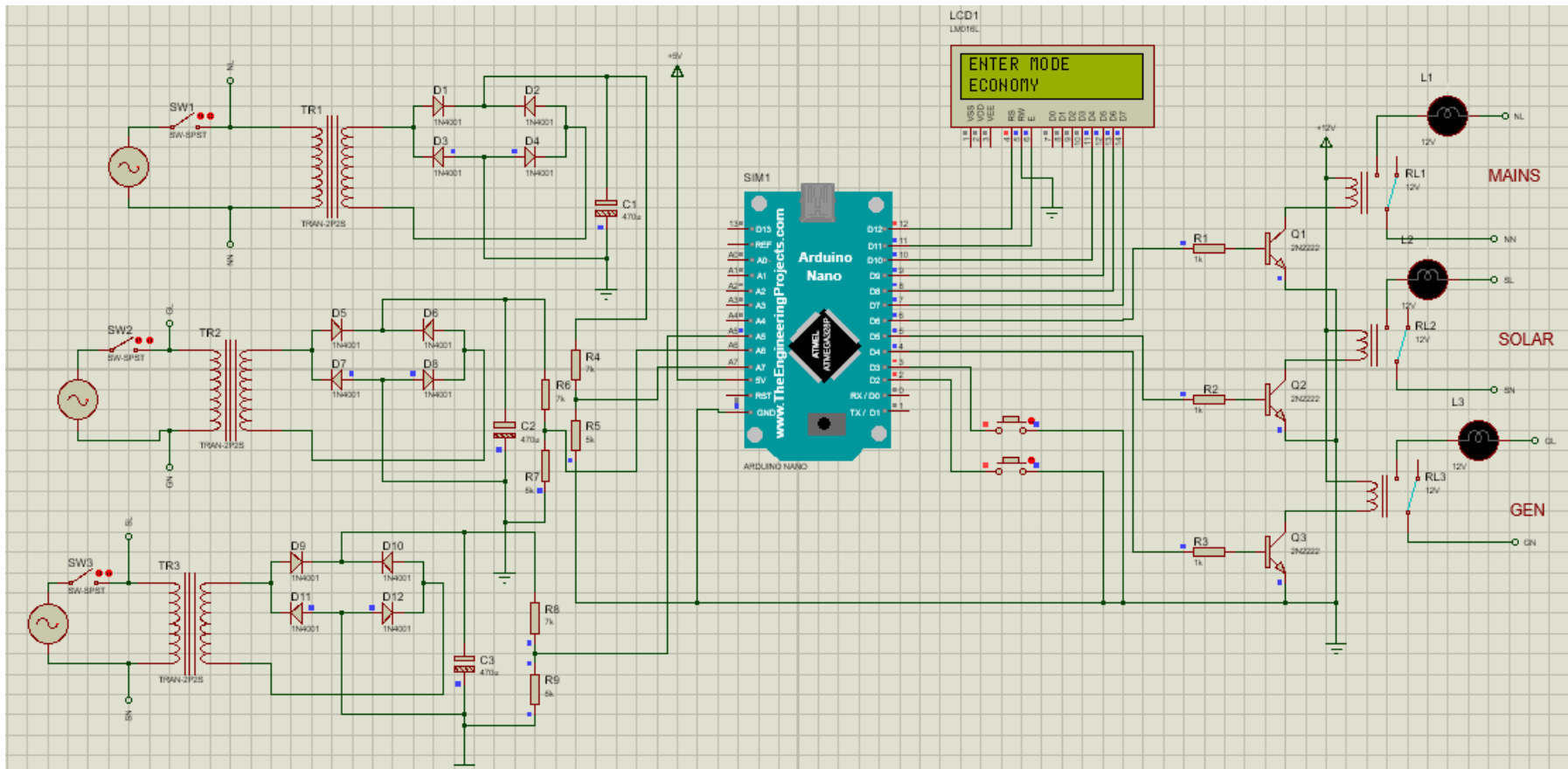
Fig. 4. The logic flow chart of the program

Fig. 5. Scenario 1

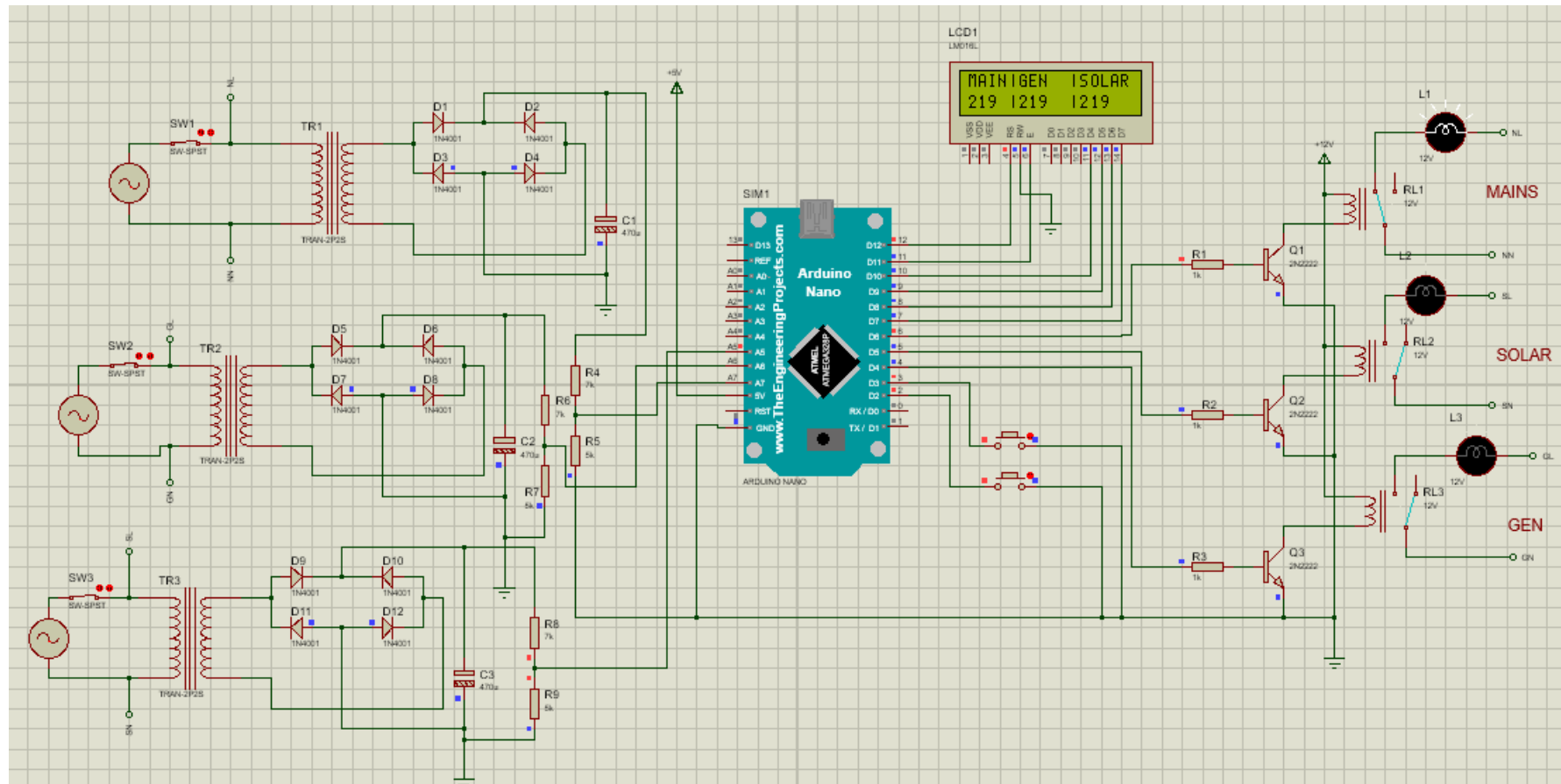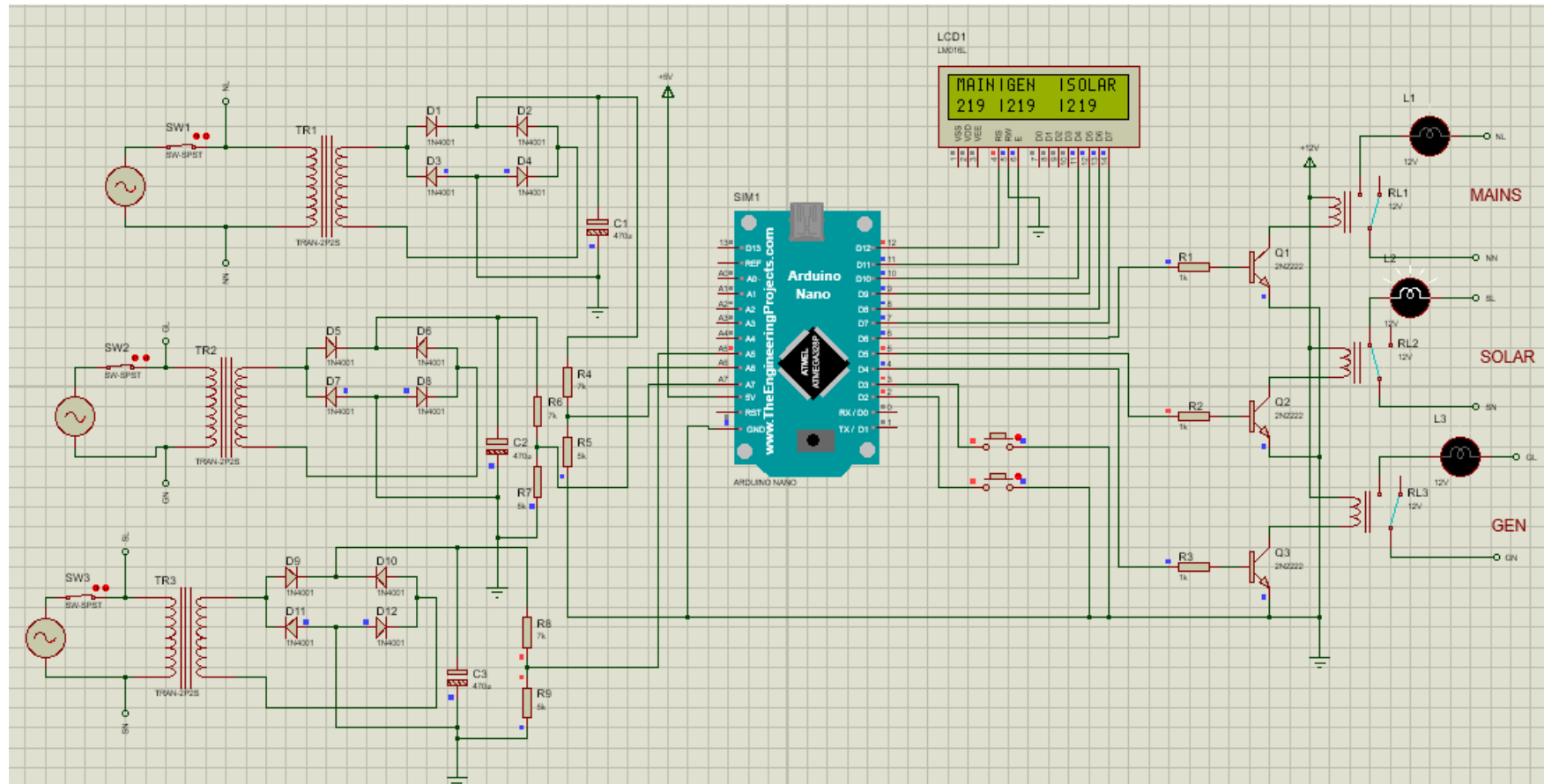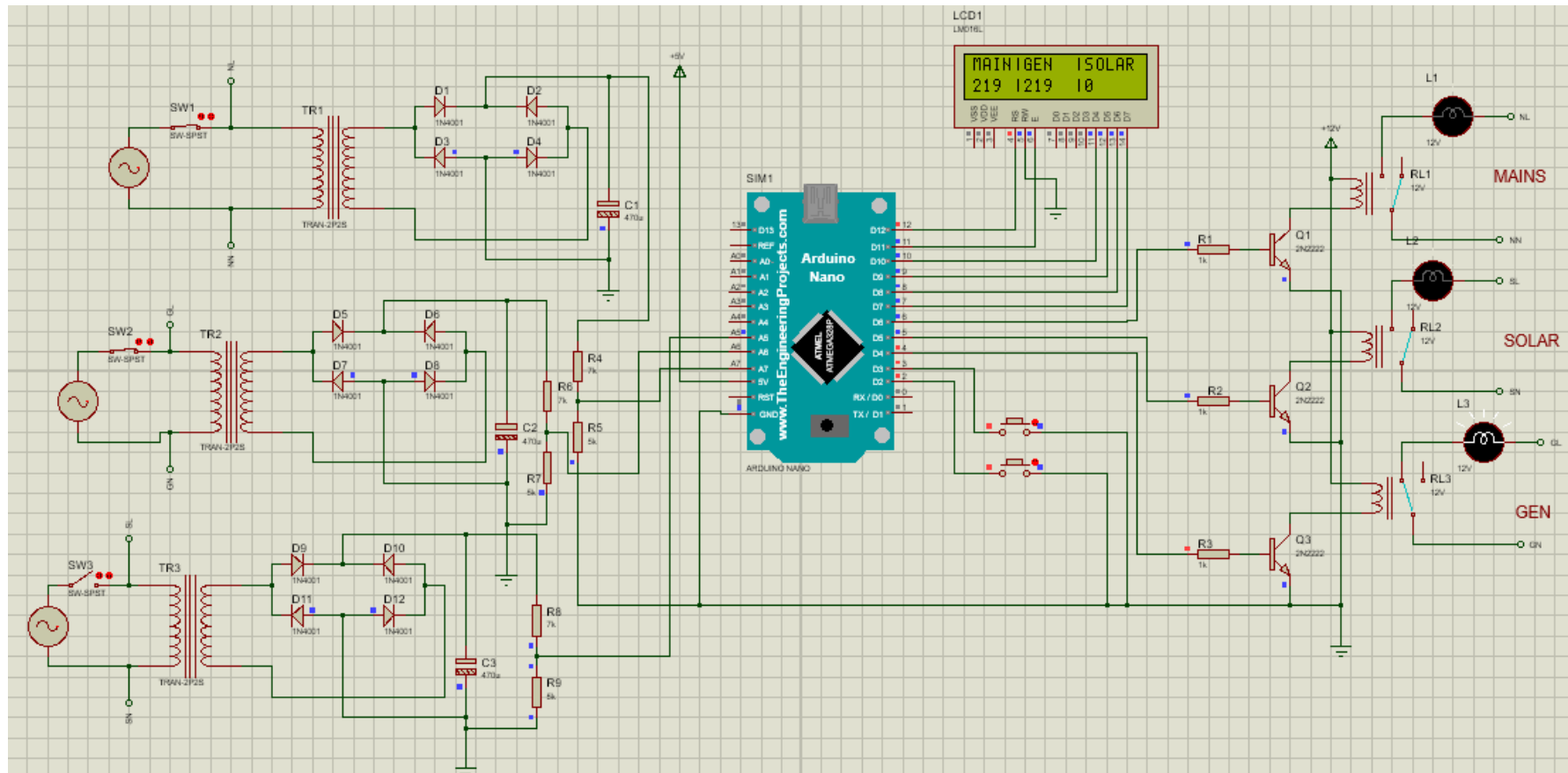**Fig. 6. Scenario 2**

Fig. 7. Scenario 3

Fig. 8. Scenario 4

Table 1. Economy priority selected

S/N	Mains Source	Generator Source	Solar Source	Output
1	On	On	On	Mains
2	On	On	Off	Mains
3	On	Off	Off	Mains
4	Off	On	On	Generator
5	Off	On	Off	Generator
6	Off	Off	On	Option to Switch to Solar
7	On	Off	On	Mains

Table 2. UP priority selected

S/N	Mains Source	Generator Source	Solar Source	Output
1	On	On	On	Solar
2	On	On	Off	Generator
3	On	Off	Off	Mains
4	Off	On	On	Solar
5	Off	On	Off	Generator
6	Off	Off	On	Solar
7	On	Off	On	Solar

From result Table 2, when UPS mode is selected it can be observed that solar is almost always selected in all conditions as long as it is available because it is the most stable source of power with best quality(voltage). Generator is selected whenever solar is not available because it is the next most stable power source with next best quality among the three. Mains is only selected whenever the other two sources are not available because in Nigeria mains is very erratic and of low quality (voltage) in most cases.

4. CONCLUSION

This work sets out the problem of prioritizing the selection of multiple sources based on need of the load. The multiple power source selector with priority option was designed and simulated to automatically select among multiple power sources based on a priority selection. The device improves economy when in economy mode and reduces the possibility of power being off completely when in UP mode. The device is able to detect the most economic source when in economy mode and the most qualitative source when in UP mode. The designed device is of great importance in place where mains electric supply is very unreliable, in such places sensitive devices get destroyed or unusable because steady/quality supply is no available.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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