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Simulated Operation of an Enhanced Production Line Counter Using Proteus Professional Design Suite

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Abstract
An essential part of contemporary industrial optimization is the ability to mimic the functioning of production line counters. This allows manufacturers to test, tweak, and improve the systems' performance before putting them into real-world settings. Focusing on the use of technologies like the Proteus Professional Design Suite, this research investigated the principles, approaches, and advantages of mimicking production line counters. Simulations allow producers to evaluate the effects of different variables on production line performance by integrating pertinent data sources, accurately representing system behaviour, and using dynamic modelling approaches. Saving money, making better decisions, minimizing risks, and optimizing processes are all possible thanks to simulated operations. To keep up with the ever-changing industrial scene, producers may use simulation tools to proactively solve problems, enhance processes, and remain competitive.

Keywords: Production, Line Counter, Improved, Simulation, Proteus Professional Design Suite

Introduction

The modern industrial landscape is changing quickly, and companies that want to stay competitive must optimize their production processes. Production line counter monitoring and operating efficiency a critical components of this improvement (Majumdar, 2017). These counters are the backbone of manufacturing process output tracking and management, offering crucial information for resource allocation and decision-making. Technology development has opened up new avenues for improving production line counter performance and usefulness (Kumar & Harms, 2004). One such breakthrough is the use of software tools such as the Proteus Professional Design Suite to enable simulated operation. Manufacturers may evaluate and improve the performance of their production line counters in a virtual setting prior to implementing them in actual situations by utilizing simulation capabilities (Herwan et al., 2023). The production line typically consists of several workstations, such as counter workstations, which decide how many products will be produced. This workstation is crucial to the efficient operation of a production line since it is frequently used to calculate the rate, speed, and length of production. As a result, it is crucial to the entire performance and functionality of a production line. Counters use a variety of technological methods to count the amount of items. The type of product processing carried out on the production line typically determines the technology to be used (Liang & Xiao, 2013). Counters are tools used in computing that record (and occasionally display) the frequency of a given event or process, frequently about time. The sequential digital logic circuit, which contains numerous output lines and a clock input line, is the one that is most frequently employed. The binary or BCD number system is represented by the values on the output lines as a number. The value in the counter is increased or decreased with each pulse applied to the clock input. A cascade of flip-flops is typically used to create counter circuits. Counters are a frequently used component in digital circuits. They can be created as standalone integrated circuits or occasionally as a component of larger integrated circuits (Bierbooms, 2012). Depending on the type of counter, the output may be encoded or a direct representation of the counts (a binary number). Examples of the formal include ring counters and counters that output Gray codes.

Most counters provide additional input signals to facilitate dynamic control of the counting sequence, such as:

- Reset – sets count to zero. Some IC manufacturers name it "clear" or "master reset (MR)".
- Enable – allows or inhibits counting.
- Direction – determines whether counts will increment or decrement.

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- Data – parallel input data which represents a particular count value.
- Load – copies parallel input data to the counts.

Counters are often classified as either synchronous or asynchronous. All flip-flops in synchronous counters share a common clock and undergo state changes simultaneously. Each flip-flop in asynchronous counters has its own clock, and the flip-flop states change at various intervals. The majority of production line counter systems make use of some sort of sensor technology to calculate how many goods are created or processed at any given time. The majority of the time, after each manufacturing cycle, these systems display the total number of tallied goods (Upadhyay, 2013). Object counters and product counters are crucial tools used in businesses, malls, and other places. To minimize human work, they automatically count the items or products. Most of these systems are implemented with the entire production process under the direction of the programmable logic controllers (PLC). These counters could occasionally offer the PLC feedback or control it needs for quality and quantity control. Manufacturers may prevent expensive interruptions and downtime in actual production processes by recognizing and resolving possible problems or inefficiencies in the virtual environment (Parr, 2003). Manufacturers may enhance the efficiency of their production line counters by experimenting with various configurations, methods, and process improvements through simulation, all without interfering with actual operations. Using tools such as the Proteus Professional Design Suite, one can simulate production line counter operations and adopt a proactive approach to industrial optimization. By utilizing advanced modelling techniques, one can increase efficiency, reduce risks, and facilitate well-informed decision-making in contemporary manufacturing environments.

Process Automation

Process automation is often the area of technology that focuses on minimizing or doing away with human control and intervention in processes. By predetermining decision criteria, sub-process linkages, and related activities, and incorporating such predeterminations into computers, human intervention is decreased (Liang & Xiao, 2013). Machines, factory processes, boilers and heat-treating ovens, switching in telecommunication networks, steering and ship stabilization, aircraft, and other vehicles with minimal human intervention, such as self-driving vehicles, are examples of equipment and control systems that are used in automation (Lahari & Venkatesan, 2017).

Production Line Automation

A production line is a series of sequential processes used in a factory where parts are assembled to create completed goods or where raw materials go through some sort of processing to create a finished good fit for consumption. Traditionally, to make raw materials functional, such as metal ores, agricultural goods like foodstuffs, or textile source plants like cotton and flax, a series of treatments must be applied. The procedures for metal include crushing, smelting, and more refinement. For plants, the valuable material must first be separated from the husks or other impurities before being prepared for sale (Hirotani, et al., 2006).

Materials and Methods

The Proteus Design Suite is a collection of software tools used mostly for automating electronic design. The program is primarily used by technicians and electronic design engineers to develop schematics and electronic prints for printed circuit board production. Depending on the scale of the designs being generated and the need for microcontroller simulation, it can be acquired in a variety of configurations. By applying a hex file or a debug file to the microcontroller portion on the schematic, Proteus's microcontroller simulation functions. The associated analogue and digital electronics are then co-simulated with it. In designing the production line counter on Proteus, the components are first selected from the component library and each component is placed on the worksheet on the schematic capture page on Proteus.

ESP32 is an IoT platform that is open source. Its hardware is based on the ESP-12 module, and its firmware is powered by the ESP32 Wi-Fi SoC from Espressif Systems. When someone refers to "NodeMCU," they typically refer to the firmware rather than the DevKit. The firmware uses the Lua programming language. It is based on the eLua project and was developed using the Espressif Non-OS SDK for ESP8266. It utilizes many open-source projects, such as lua-cjson and spiffs. The ESP32 was chosen for this project because it comes equipped with an internal WiFi chip that enables it to connect to other WiFi devices and serve as a WiFi hotspot, eliminating the need for an additional WiFi module. Furthermore, the GPIO (general purpose input/output) pins on the ESP3 make it easy to interface with I2C and SPI devices.
Features

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- Version : DevKit v1.0
- Breadboard Friendly
- Light Weight and small size.
- 3.3V operated can be USB powered.
- Uses wireless protocol 802.11b/g/n.
- Built-in wireless connectivity capabilities.
- Built-in PCB antenna on the ESP-12E chip.
- Capable of PWM, I2C, SPI, UART, 1-wire, 1 analog pin.
- Uses CP2102 USB Serial Communication interface module.
- Arduino IDE compatible (extension board manager required).
- Supports Lua (alike node.js) and Arduino C programming language.

In this work, the ESP32 serves as the microcontroller which interprets the state of the IR sensor and increments the object count. It also serves as the WI-FI hotspot, allowing for object count data to be accessed via the webserver.

The source code or intelligence governing the entire system is written in C++ language using the Arduino IDE (Integrated Development Environment).

The Arduino IDE is an open-source software containing a text editor for writing codes, a message area, a text console, and a toolbar containing buttons for functions such as serial monitor, upload, compile, board selection, COM port selection, programmer selection, library update and download, sketches, examples, etc. This software developed by Arduino.cc connected the Arduino hardware as well as other boards such as ESP32, NodeMCU, LOLINE, etc., to upload programs and communicate with them. The Arduino IDE serves as the compiler, converting the C++ code (.ino) to machine code (.hex) which the microcontroller understands. The following steps were taken in using the Arduino IDE:

i. Download the Arduino IDE from Arduino.cc/en/software.
ii. Install the Arduino IDE on a computer, in this case, a 64Bit Windows 10.
iii. Open the Shortcut Icon on the desktop.
iv. Click on File on the tools bar and select Preferences.
v. On the Additional boards bar, write the following https://dl.espressif.com/dl/package_esp32_index.json.
vi. Click on OK. This would add ESP32 to the board options on the IDE.
vii. On the tools bar, select Tools and click on Boards. Scroll to ESP32 Dev Kit and select.
viii. On the tools bar, select Tools click on Port and select the COM port.
ix. On the text editor, input the code.

Figure 1 illustrates the flowchart algorithm on which the C++ program is developed.

The designed production line counter circuit and C++ program must however be confirmed to work properly. Thus, simulation is required to ensure this. Proteus professional suite provides tools for the simulation of circuits. However, considering that ESP32 is not available on the Proteus component library, a substitute microcontroller must thus be used in the simulation of the production line counter. Thus, an Arduino Nano is chosen as the substitute microcontroller in simulating the counting and logging sequence of the production line counter circuit.

The Arduino Nano is a development board from Arduino.cc built on the 8bit ATMEGA 16/328P microcontroller. The Arduino Nano has 13 digital pins labelled 0-13 and 8 analog pins labelled A0-A7. As a transistor-transistor logic-based circuit, it requires an operating voltage of 5V.

To simulate the operation of the production line circuit, the IR sensor is replaced with a push button to simulate the passing of an item across the view of the IR sensor. The circuit designed for the simulation of the production line counter is illustrated in Figure 2 and Figure 3.

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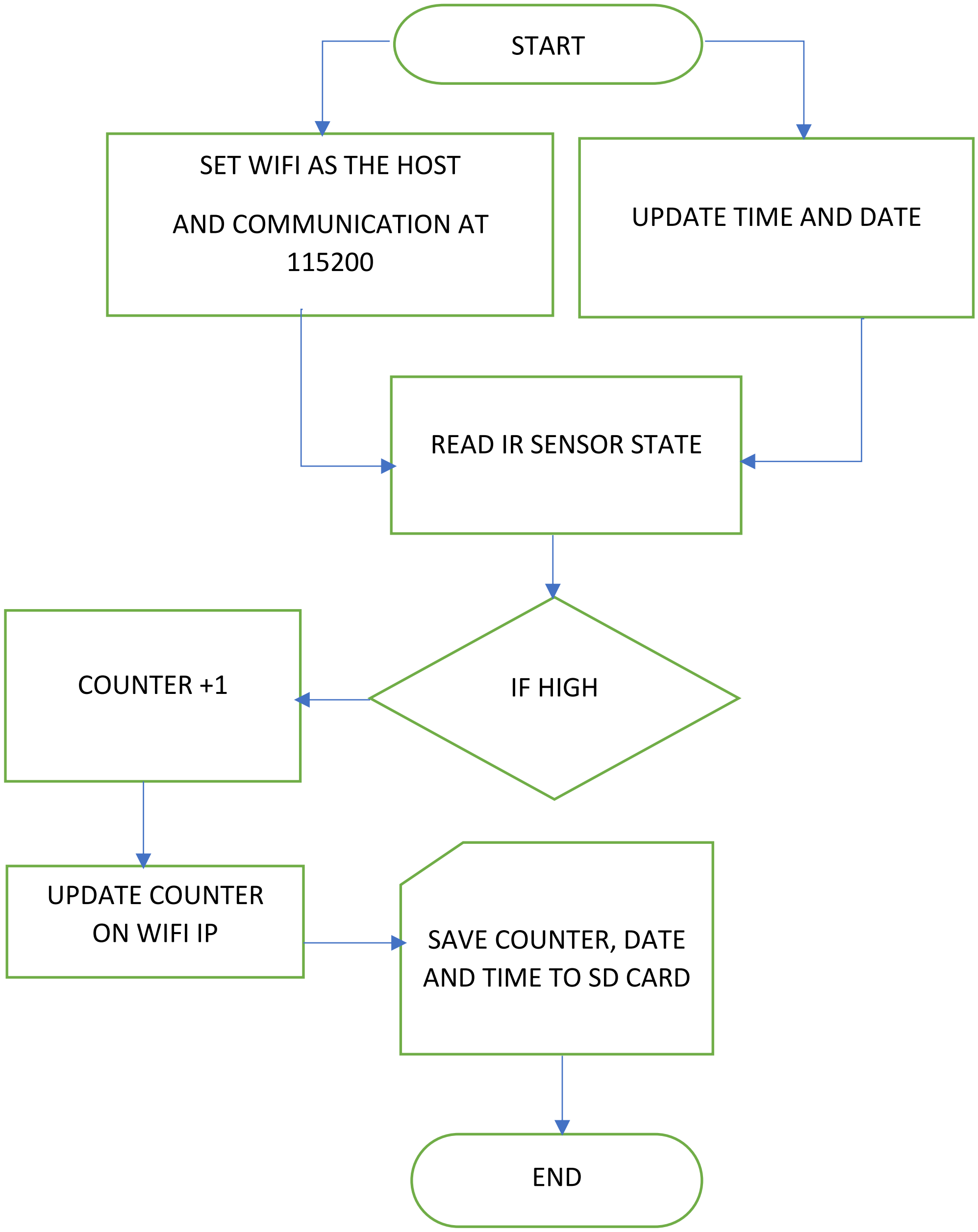

Figure 1: C++ Flowchart

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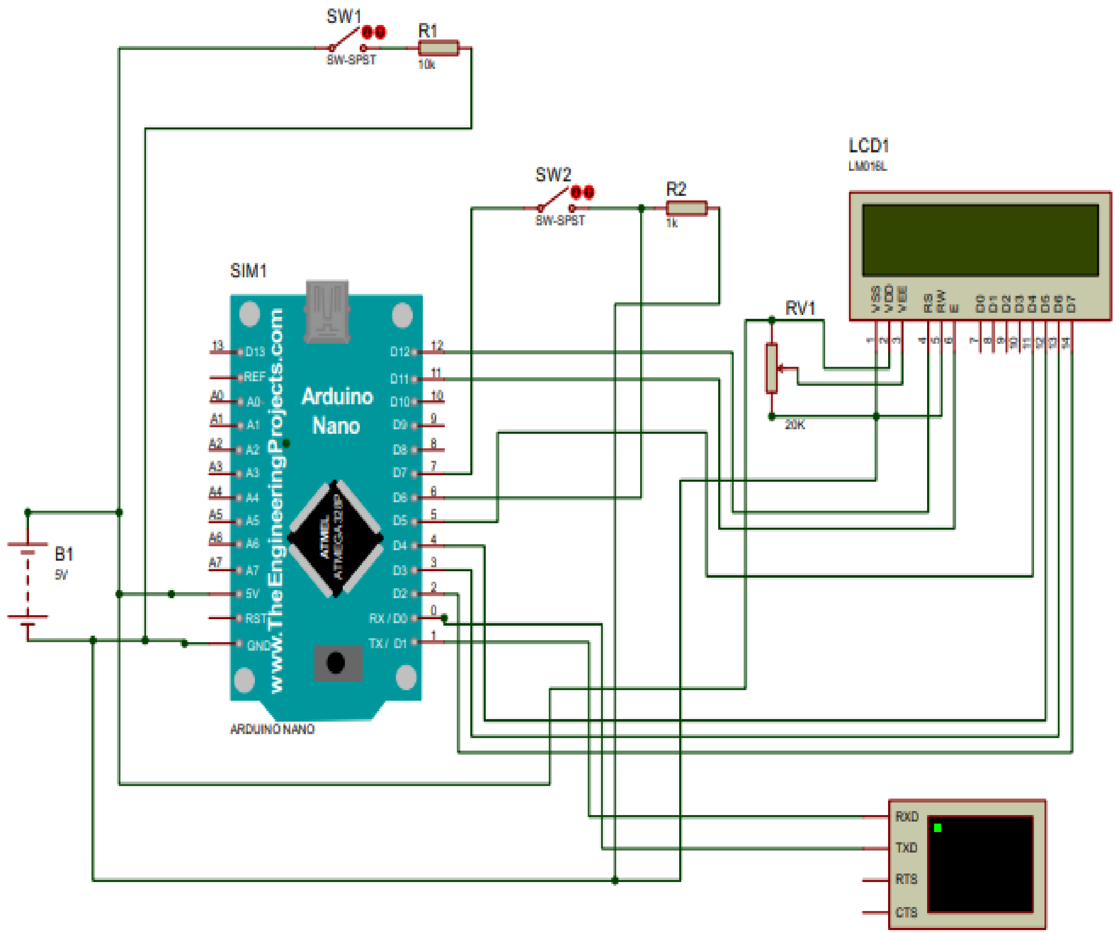

Figure 2: Simulation Circuit without RTC

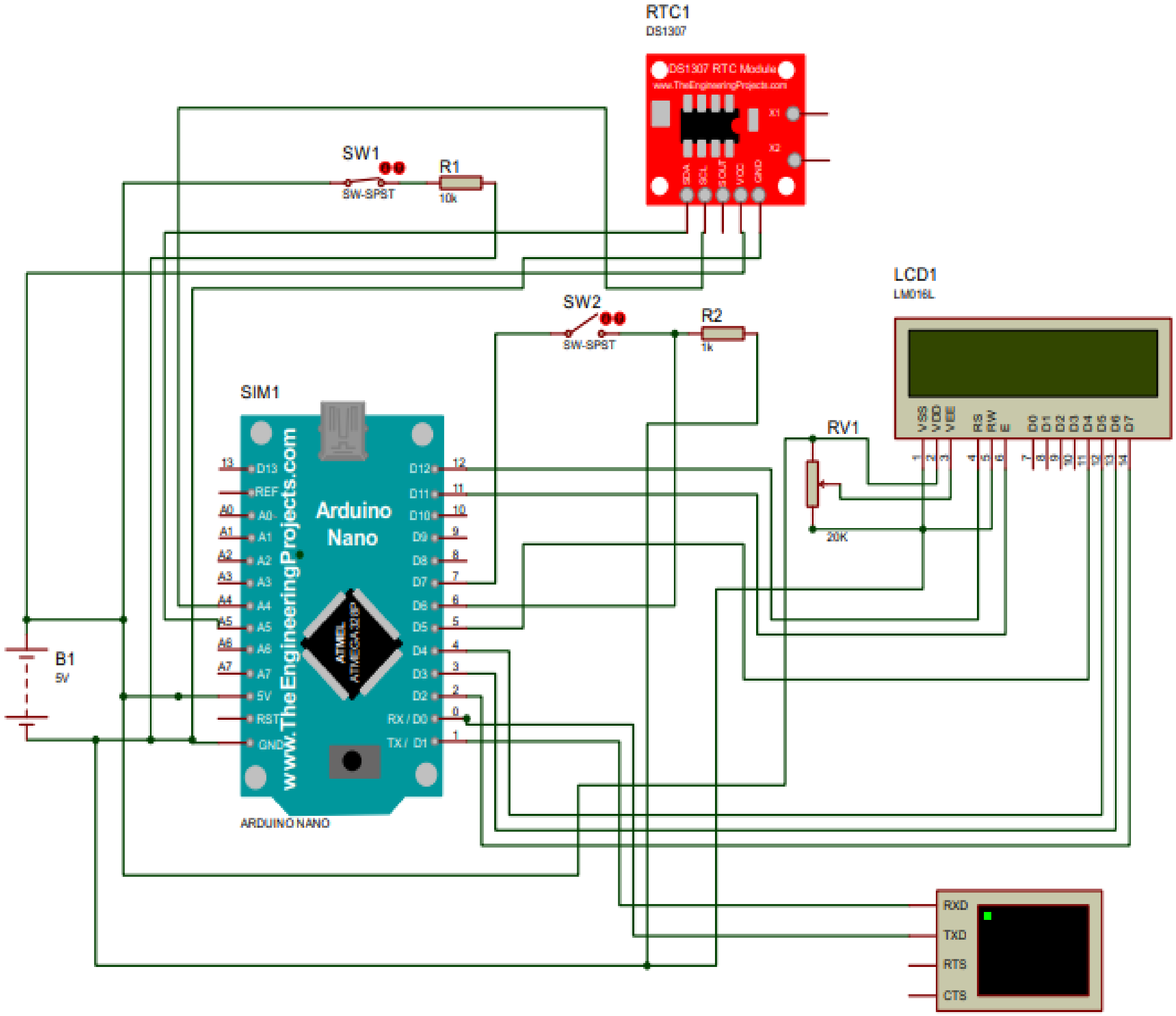

Figure 3: Simulation Circuit with RTC

Results

The simulation of the production line counter is carried out with only components of the counter circuit assembled on the schematic. The counter circuit simulation consists of the Arduino Nano, the LCD, the push button, the RTC, and the switch. The results obtained from this simulation are presented in Figures 2-3.

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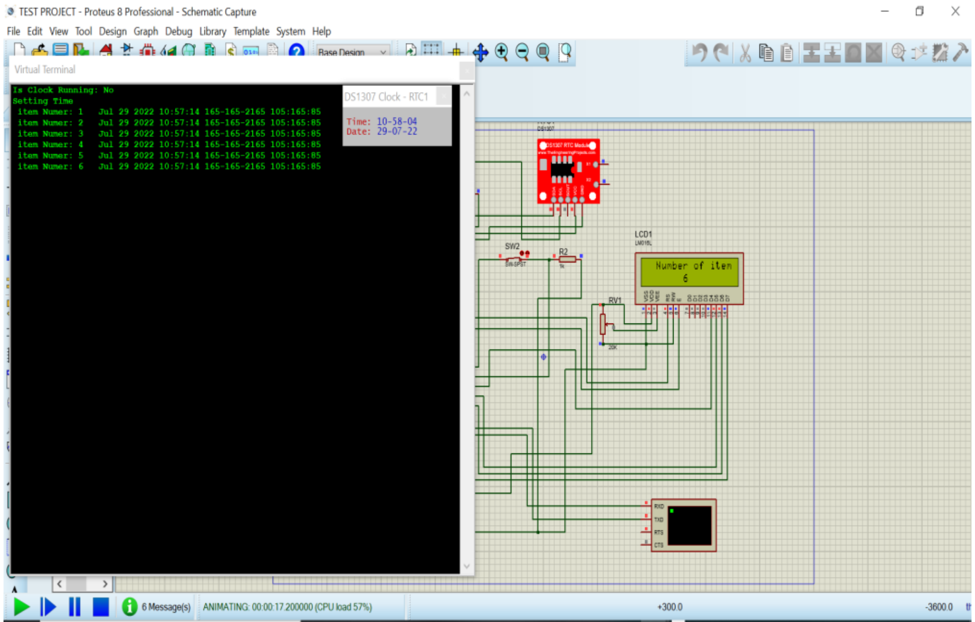

Figure 4: Simulation of the Production counter's counting sequence showing the number of items at 6

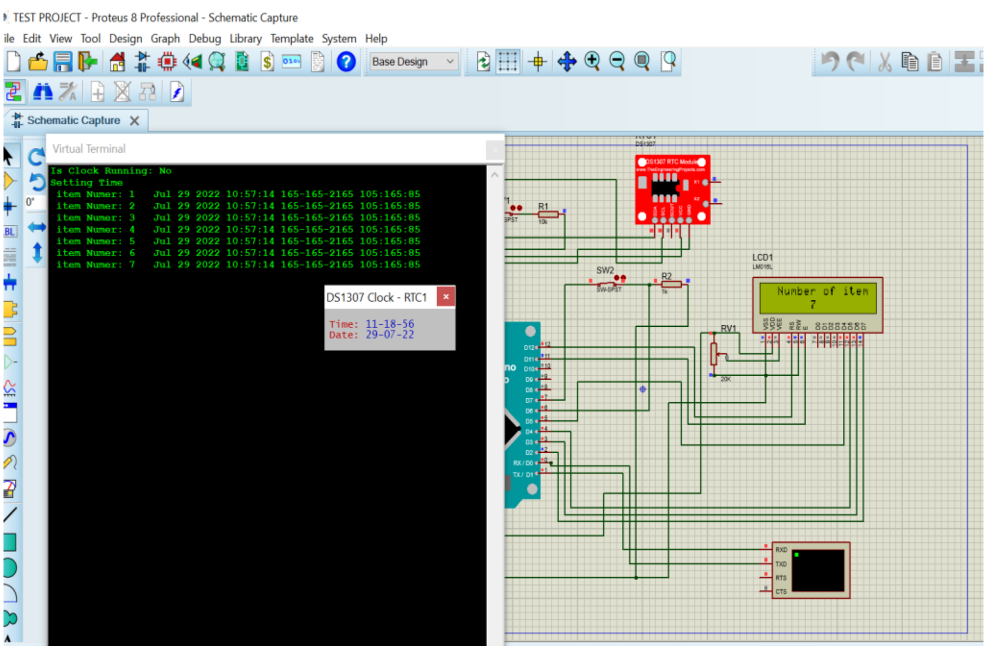

Figure 5: Simulation of the Production counter's counting sequence showing the number of items at 7

Figures 4 and 5 show the Proteus simulation window of the production line counter circuit consisting of the virtual terminal which displays the state of the button (1 or 0), indicating when the button has been pressed or not and the number of items counted. The RTC, Arduino Nano, push button and 10K potentiometer can also be seen in the schematic.

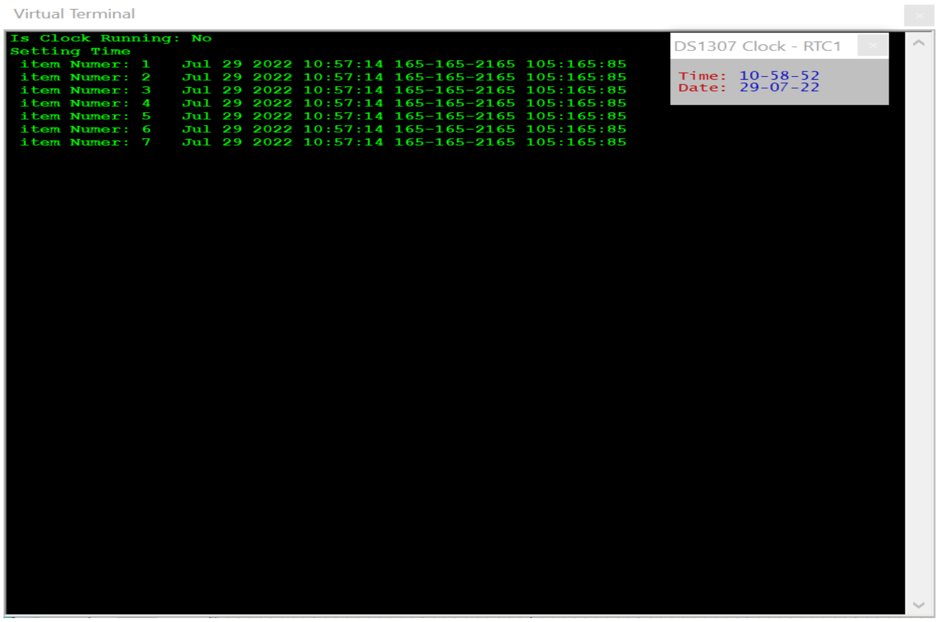

Figure 6: Virtual Terminal Display of Button State and Item Count.

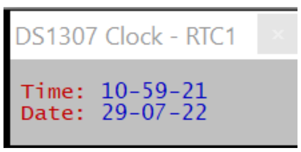

Figure 7: Real Time Clock Data showing time and date.

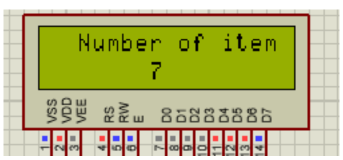

Figure 8: LCD displaying the number of counter items.

Figures 6, 47 and 8 show the virtual terminal, the RTC date and Time values and the number of Items counted is displayed on the LCD respectively.

Discussion

The design of the production line counter executed on Proteus Professional Suite provided a CAD platform through which circuit characteristics as well as parameters and components were easily determined. The components used in the design of the production line counter circuit were all selected from the component library on Proteus. This allowed for troubleshooting and testing of the characteristic behaviour of the production line circuit through simulation. Through the use of the simulation tool on Proteus Professional, components required for the construction of the production line counter were first connected and tested virtually. This allowed for the performance or characteristic behaviour of the circuit, code and expected results to be analyzed, debugged, corrected and reconstructed before the purchase of components and construction of the hardware. This minimized the tendency of errors as a result of the code not functioning as desired or hardware damage due to improper component selection. From the results obtained during simulation and testing of the production line counter, it was observed that the IR sensor was able to effectively detect and count ach object that passed within 5cm of its view (receiver and transmitter). From the test results obtained, a total of 7 objects were counted. Counting or detection was observed to occur at an interval of 500milli-second. The time and date of each count were also observed to be logged on the SD Card as well as the count number. Through the use of RTC and SD-Card modules, the production line counter developed in this work demonstrated that adequate documentation and storage of production data could be automated using C++.

Conclusion

Using Proteus Professional Design Suite to model the operation of an upgraded production line counter presents a viable option for manufacturing process optimization. This technology offers an economical way to assess and improve production line efficiency through careful design and simulation, which raises overall productivity and lowers operating expenses. Through the use of Proteus Professional Design Suite, producers may effectively simulate and assess diverse situations, detect any obstructions, and execute focused enhancements. This simplifies production procedures and encourages creativity and flexibility in the dynamic field of industrial manufacturing. Future efficient and sustainable manufacturing systems will surely be shaped by the incorporation of simulation tools such as Proteus Professional Design Suite, especially as technology develops.

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