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Automatic Size Identification and Bottle Filling Plant using PLC and SCADA

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ABSTRACT: Liquid filling is an essential feature in manyindustries such as pharmaceuticals, chemical,food and beverage, paint etc.The purpose of the paper is to design,implement, visualize and test an automatedsystem for filling liquids from a main tank intobottles of different size. The entire process isautomated with proximity sensors, controlvalves and programmable logic controllers.The monitoring and data acquisition is donewith the help of SCADA. This helps to transferthe data from the controller to anotherdatabase for documentation purposes. Dynamicvisualization is also made possible withSCADA.

KEYWORDS: PLC, SCADA, Process Automation, Bottle Filling, Proximity Sensors.

I.INTRODUCTION

Industrial Automation has grown exponentially in the recent times. Development of closed loop controllers and accurate and dynamic data capturing and analysis has helped different manufacturing and processing industries to improve their product quality, increase production rate, reducing manpower, maintain better data handling and reducing cost of mass production.Continuous monitoring and control are essential for automating any process industry and this can be done with the help of PLC and SCADA.

1.1 Programmable Logic Controllers (PLC)

A PLC is a solid state/ computerized industrial computer that performs discrete or sequential logic in a factory environment. It was originally developed to replace mechanical relays, timers, counters etc. PLCs are used successfully to execute complicated control operations in a plant by monitoring crucial process parameters and adjust process operations accordingly. A sequence of instructions is programmed by the user to the PLC memory and when the programme is executed, the controller operates a system to the correct operating specifications.
PLC provides internal timers, counters, memory bits etc. The timers are used to generate a delay in working time. ON delay timers and OFF delay timers are used in PLCs in general. Counters are used to count the pulse generated within the system (e.g.: from a sensor) and store the number of counts. Up counters and Down counters are widely used in PLCs to keep records of the count.
The PLCs can be connected with various input and output devices. Pushbuttons, toggle switches, proximity sensors etc. are some of the commonly used inputs. LED lights, relay coils, solenoid valves etc. are some of the output devices.

1.2 Supervisory Control and DataAcquisition (SCADA)

Earlier PLCs used to be black boxes. You program the PLC, download the program in it, and it will run for years. But the problem with this was that you really don't know what is happening inside the PLC. Now a days automation system contains PLCs and SCADA software. If we use PLC and SCADA combination the advantages is that you have better monitoring and control of the plant and also you have access to the information the way you want. SCADA enables engineers, supervisors, managers and operators to view and interact with the workings of entire operations through graphical representation of their production process.

SCADA runs on a PC and is generally connected to various PLCs and other peripheral devices. It enables you to generate applications for the most demanding requirements of plant operators tailored precisely to the needs of each

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plant. SCADA constantly gather data from the plant in real-time, stores and process it in the database, evaluate and generates alarms, displays information and can issue instructions to the PLCs in the plant.

II. METHODOLOGY

The proposed system contains a conveyor system and a filling unit. The conveyor system is in-line type and is driven using a DC motor controlled by the PLC through a relay. The conveyor stops automatically when the filling process takes place and resumes after each bottle is filled.
The filling unit contains a control valve connected to the main tank, three proximity sensors to detect the presence and size of the bottles. The sensors detect the bottle and stops the conveyor. The bottles used are of different heights. The sensors are arranged vertically in such a way that only the bottom sensor is activated when small bottle is passed, both bottom and middle sensors get activated for medium bottles and all three sensors are activated for large bottles. Depending on the size of the bottle detected, the PLC will control the time needed for filling the bottle automatically.
The SCADA system is integrated with the PLC to collect the information such as no: of bottles filled, quantity of liquid filled, quantity of liquid remaining in the main tank, detecting faults, plotting production vs time graph, and obtaining dynamic visualization.

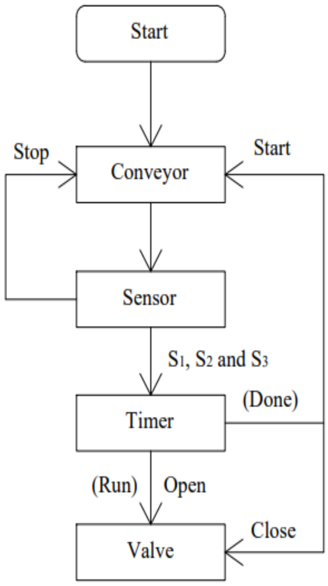

Fig.1

Algorithm

1. Start the Conveyor System
2. Bottle is sensed by the set of sensors and the size of the bottle is identified.
3. The conveyor is stopped.
4. Valve is opened for filling.
5. Timer corresponding to the detected bottle size runs.
6. When timer completes the pre-set time, the valve is closed and the conveyor restarts.
7. The count of corresponding bottle is stored in the counter.
8. Data regarding the conveyor system, sensors activated and no: of bottles filled are taken by the SCADA for visualization.
9. An excel file is updated with the no: of bottles filled for each size, total quantity of fluid filled, remaining quantity in the tank, working status of the sensors etc. by SCADA.

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Process Diagram

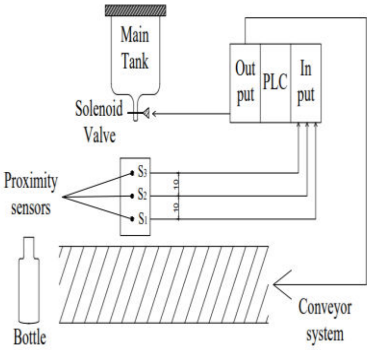

Fig.2

The physical arrangement of the proposed filling system is shown in fig.2. The differently sized bottles enter the conveyor system from the left. The three proximity sensors are positioned vertically at 10cm, 20cm and 30cm from the conveyor base. The height of the bottles are 15cm, 25cm and 35 cm for small, medium and large respectively. When the bottle reaches below the valve of the main tank, sensor or sensors corresponding to the bottle's height will detect the presence of the bottle and the conveyor will stop for filling.

PLC Ladder Logic

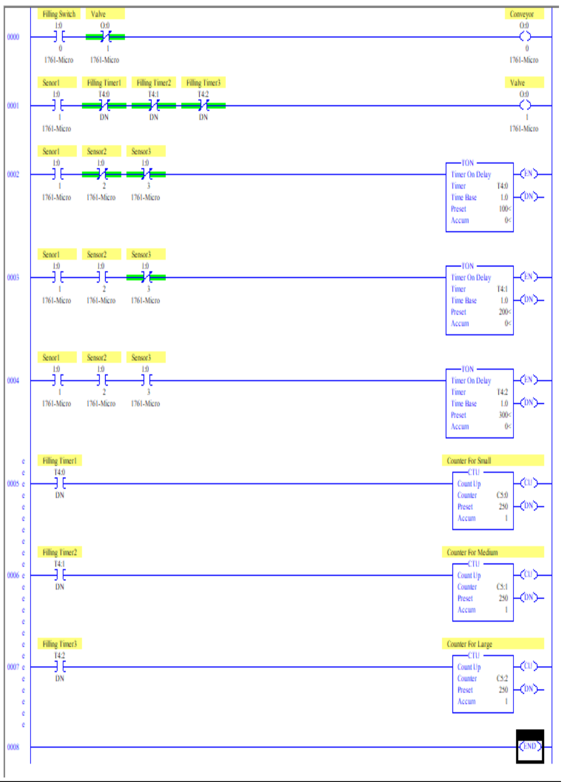

Fig.3

A toggle switch I:0.0/0 (Filling Switch) is used to start and stop the filling system. Three PLC input address I:0.0/1, I:0.0/2, I:0.0/3 (s1, s2 and s3) are used for the three sensors. S1 for the bottom sensor, s2 for the middle sensor and s3 for the top sensor. Timers T4:0, T4:1 and T4:2 are used for controlling the filling time for small, medium and large bottle respectively. Counters C5:0, C5:1 and C5:2 are used to keep count of small, medium and large bottles filled.

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Output O:0.0/0 (conveyor) can be given to a relay coil to control the motor for the conveyor system and output O:0.0/1 (valve) can be given to the solenoid valve.

SCADA System

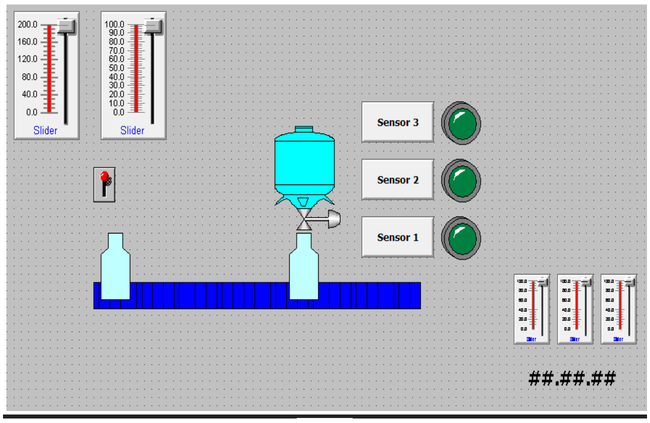

Fig.4

The visualization of the filling system in SCADA software is shown in fig.4. The sensor inputs and outputs from conveyor and valve are taken from the PLC and corresponding representation is shown in the SCADA display. Depending upon the size of bottles filled, the count of each type of bottle and the total quantity of fluid filled will be calculated by the SCADA system. By setting the initial quantity of the fluid in the main tank, the remaining quantity after filling each bottle is calculated.

III. RESULTS

PLC Results

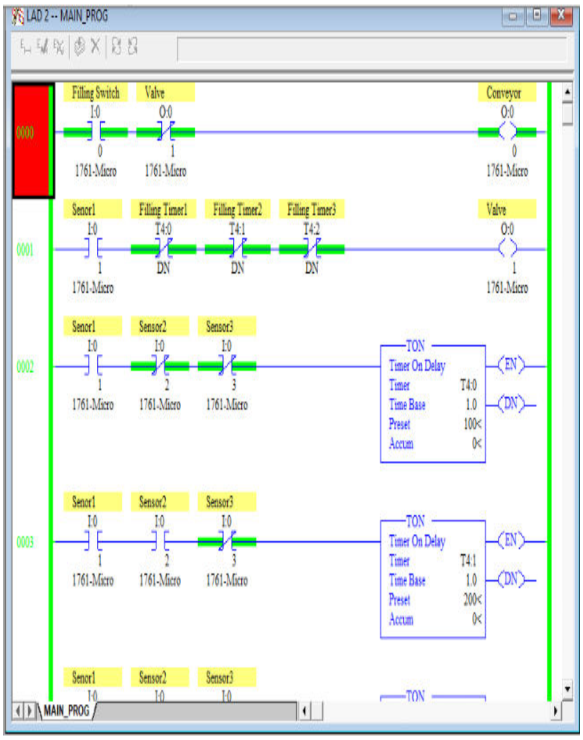

Fig.5

The filling switch is turned ON and the conveyor starts to run.

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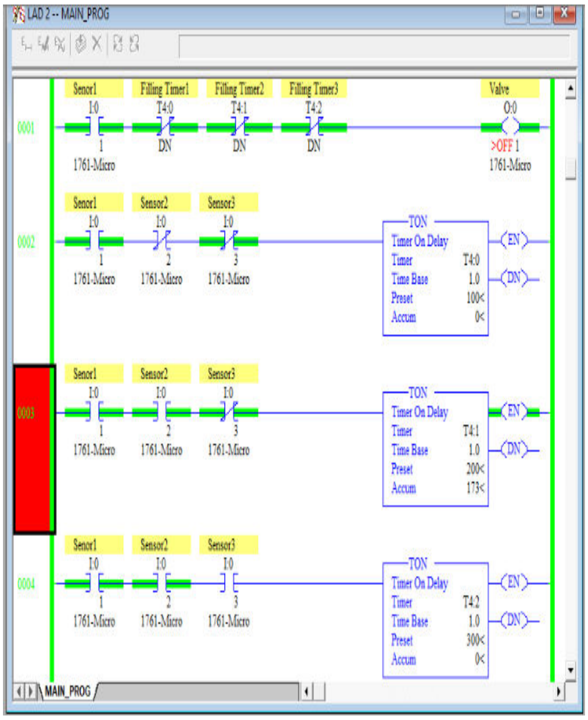

Fig.6

A medium size bottle is sensed by sensors S1 and S2. This will activate T4:1 and the soleniod valve is opned.

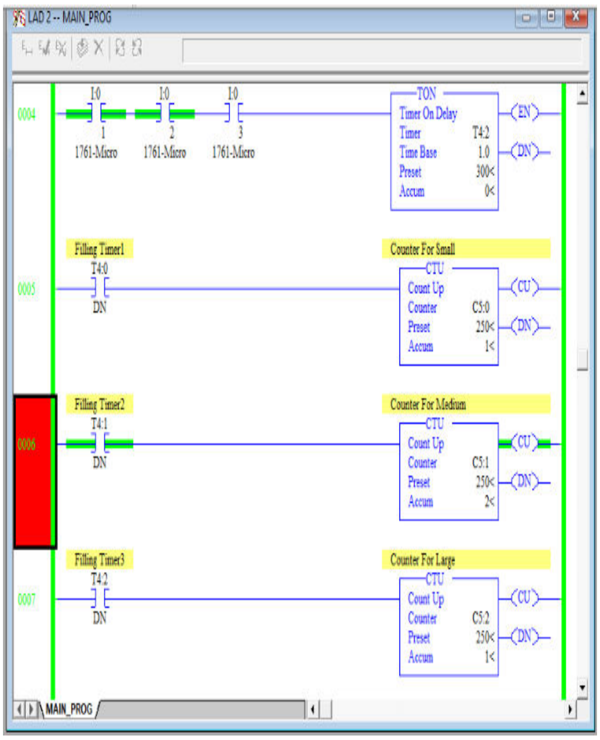

Fig.7

After the timer T4:1 is done, the counter C5:1 for medium sized bottle is updated.

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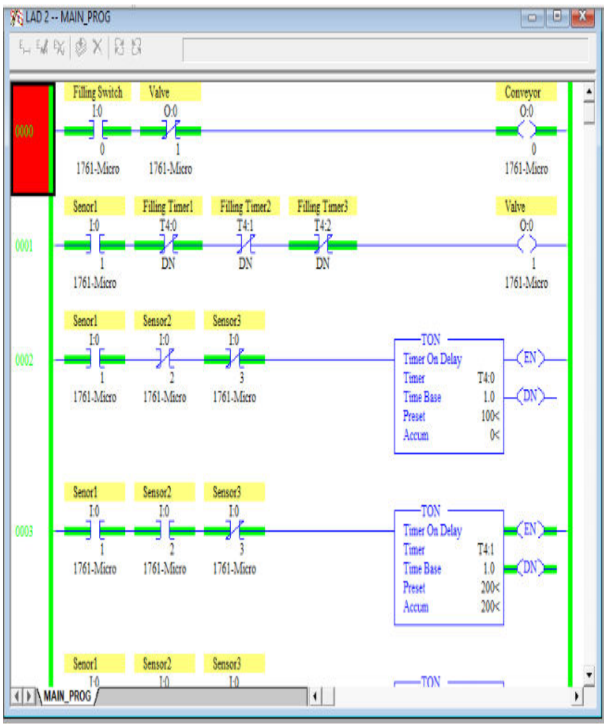

Fig.8

The timer done bit will close the valve and restarts the conveyor.

SCADA Results

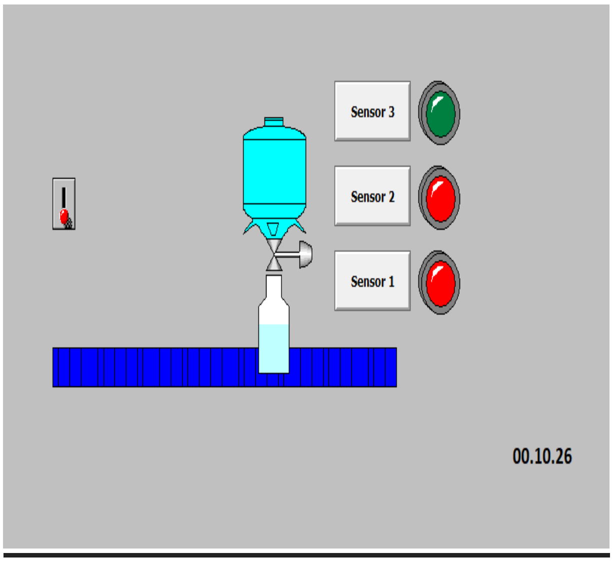

Fig.9

The movement of conveyor system, sensors activated, quantity of liquid filled and process run time is visualised using the SCADA software.

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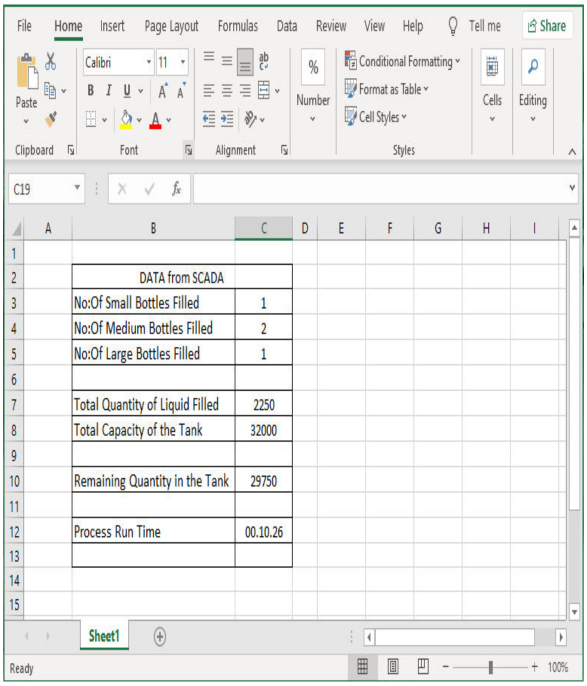

Fig.10

The various data such as no: of bottles filled, quantity of liquid filled, remaining quantity in the tank and process run time are transferred into an excel file and dynamically updated while the system runs

.

IV. FUTURE-SCOPE

The process can be extended by adding capping unit and sorting unit. The capping unit can close the bottles after they are filled and a size wise sorting system can sort the bottles depending on their size by using a similar vertical sensor arrangement as that of the proposed system.

V. CONCLUSION

An automated system is programmed using Allen Bradley's RS Logix 500 software which is compatible with MicroLogix 1000 PLC. The programming language used is ladder logic. The ladder program is simulated with RS Logix Emulate 500. The input and output data from the PLC ladder is transferred to InTouch SCADA software by interfacing. The SCADA is scripted in such a way that from the received data from the PLC, the no: of bottles filled, quantity of liquid filled, remaining liquid in the tank, run time of the process etc. can be calculated automatically and send to an external excel file for documentation. Dynamic visualization of the process is also provided by the SCADA software for monitoring purpose.

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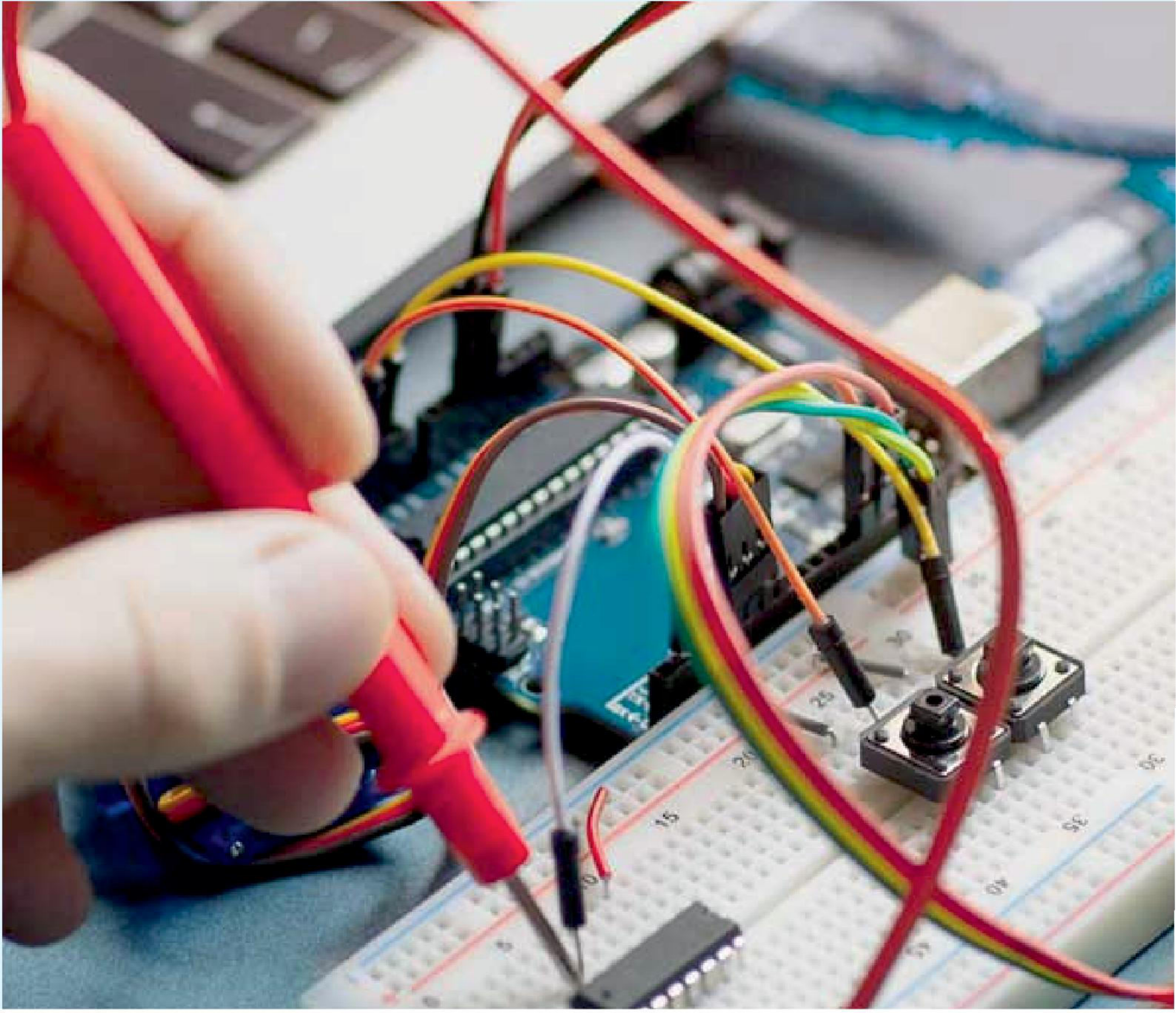

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