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MONITORING AND DATA ACQUISITION SYSTEM FOR STATIONARY WATER TANKS THROUGH IIOT

J. L. Sanchez-Cuevas*[2], J. E. Soto-Soto[1], J. I. Hernandez-Vega[1], L. A. Reynoso-Guajardo[1], E. Reyes-Varela[1] and G. E. Allen-Cobos[1]

[1]National Institute of Technology of Mexico/ Nuevo Leon Institute of Technology, Department of Graduate Studies and Research, Av. Eloy Cavazos 2001, Col. Tolteca, C.P 67170, Guadalupe, Nuevo Leon, Mexico.

[2]National Institute of Technology of Mexico/Saltillo Institute of Technology, Department of Computer Systems Engineering, Av. Venustiano Carranza 2400, Col. Tecnológico, C.P 25280, Saltillo, Coahuila, Mexico.

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***Corresponding Author**
J. L. Sanchez-Cuevas
National Institute of Technology of Mexico/Saltillo Institute of Technology, Department of Computer Systems Engineering, Av. Venustiano Carranza 2400, Col. Tecnológico, C.P.

ABSTRACT

This article addresses the importance of monitoring the water level in a stationary tank and controlling the water pump in the supply of potable water through Industrial Internet of Things (IIoT). The issues that arise when these measures are not implemented are explored, including the possibility of water and energy waste, as well as the lack of water supply during critical moments. Various solutions and technologies available for water level monitoring and pump control are presented, and their benefits and limitations are discussed. The objective of this research is to propose a data acquisition system through the Industrial Internet of Things, applied to the monitoring of stationary tanks by means of sensors suitable for taking level, flow and temperature measurements. These will allow us to observe the behavior and relationship between them. The proposal is oriented to the use of Industry 4.0 based on a prototype development methodology. The results with the prototype are the digitalization of the data that are sent to a cloud that is accessed through an interface to display the data in real time, as well as their historical records to visualize their behavior, alerts and feedback for the activation of actuators. The operation of the prototype with the Particle Photon card showed no loss of information, stable, versatile and low-cost.

KEYWORDS: Data acquisition system; Industry 4.0; Industrial Internet of Things; cloud; real time.

1 INTRODUCTION

Industry in Mexico represents an average contribution of 17% of the National Gross Domestic Product (GDP) and employment generation.[1] This type of industry has suffered a delay in the innovation of its productive processes and implementation of emerging technologies that make it competitive. It is important to implement innovation processes with Industry 4.0 technologies such as the Industrial Internet of Things and thus face global competitiveness with effective and efficient processes.[2] In Mexico, an intelligent industry has not been developed, where there are data acquisition systems that contribute to the digitization of processes and thus help to generate an intelligent industry, where decision making is based on data acquired in real time and in integrated databases, data that can be analyzed under intelligent computing algorithms that establish relationships between variables, pattern recognition and can establish forecasts.[3] Monterrey, Nuevo Leon has problems related to seasonal water shortages, mainly due to excessive and unconscious use due to the increase in the number of companies located in this city. To deal with these problems it is necessary to know the exact storage levels at key points in the city, to know when to act and that the measures are proportional to the level of consumption present at that moment. So a prototype was made with stationary tanks and supply pumps from ITNL facilities to test an experimental scenario.

2 MATERIALS AND METHODS

2.1 MATERIALS

For the development of the IoT Node it was necessary to have the following materials: temperature, humidity, level and flow sensor, output devices in this case a pump and an indicator and for the processing of the readings the IoT device "Particle Photon".

2.1.1 DHT11 TEMPERATURA & HUMIDITY SENSOR

The DHT11 is a low-cost, easy-to-use digital temperature and relative humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and displays the data as a digital signal on the data pin (no analog output). It is quite simple to use in both hardware and software. The DHT11 sensor features a calibrated digital signal, ensuring high stability and reliability over time. The sensor integrates resistive sensors for temperature (thermistor) and another for humidity. It can measure humidity in the range from 20% to 90% and temperature in the range from 0ºC to 50ºC.[4]

The DHT sensor measures the electrical resistance of the thermistor to measure temperature and the variation of the capacitance of the capacitive sensor to measure relative humidity of the air. These values are then converted into a digital signal that can be read by a microcontroller or similar device, in this case for a Particle Photon microcontroller. The Sensor is shown in Figure 1.

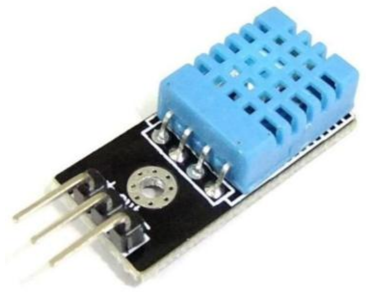

Figure 1: DHT11 sensor.

2.1.2 HC-SR04 ULTRASONIC SENSOR

The HC-SR04 Ultrasonic Distance Sensor is a sensor used for detecting the distance to an object using sonar. It's ideal for any robotics projects by detecting how close or far the objects are from the sensor.

The HC-SR04 uses non-contact ultrasound sonar to measure the distance to an object and consists of two ultrasonic transmitters (basically speakers), a receiver, and a control circuit. The transmitters emit a high frequency ultrasonic sound, which bounce off any nearby solid objects, and the receiver listens for any return echo. That echo is then processed by the control circuit to calculate the time difference between the signal being transmitted and received. This time can subsequently be used, along with some clever math, to calculate the distance between the sensor and the reflecting object. The HC-SR04 sensor works best between 2cm – 400 cm (1" - 13ft) within a 30-degree cone and is accurate to the nearest 0.3cm.[5] In this case the sensor will measure the level of the water in cm. The Sensor is shown in Figure 2.

Figure 2: HC-SC04 Ultrasonic Sensor.

2.1.3 YF-S201 HALL EFFECT WATER FLOW METER / SENSOR

This sensor sits in line with your water line and contains a pinwheel sensor to measure how much liquid has moved through it. There's an integrated magnetic hall effect sensor that outputs an electrical pulse with every revolution. The hall effect sensor is sealed from the water pipe and allows the sensor to stay safe and dry. The sensor comes with three wires: red (5-24VDC power), black (ground) and yellow (Hall effect pulse output). By counting the pulses from the output of the sensor, you can easily calculate water flow. Each pulse is approximately 2.25 milliliters. Note this isn't a precision sensor, and the pulse rate does vary a bit depending on the flow rate, fluid pressure and sensor orientation. It will need careful calibration if better than 10% precision is required. However, its great for basic measurement tasks.

The pulse signal is a simple square wave so its quite easy to log and convert into liters per minute using the following formula. Pulse frequency (Hz) / 7.5 = flow rate in L/min.[6] In this case the sensor will measure the flow of the water in L/min. The Sensor is shown in Figure 3.

Figure 3: YF-S201 Hall Effect Water Flow Meter / Sensor.

2.1.4 RELAY

The isolated relay module is an electronic device that allows you to control high power circuits using low power signals from a microcontroller or other digital circuit. It features four independent relays, each capable of switching loads up to 10 amps at 250VAC or 30VDC. The module is isolated, meaning that the control signals and the switched circuit are electrically separated to prevent interference and protect your control circuitry. It operates on either 5V or 3.3V power supplies, making it compatible with a wide range of microcontrollers and digital circuits. The module can be controlled using simple digital signals, making it easy to interface with microcontrollers and other digital circuits. It is commonly used in industrial control systems, home automation projects, and other applications where high power switching is required.[7]

The pump can be switched on and off by means of the 220V contactor coil using this relay. The module is shown in Figure 3.

Figure 4: Relay Module.

2.1.5 PARTICLE PHOTON

The Photon is a tiny Wi-Fi IoT device for creating connected projects and products for the Internet of Things. It's easy to use, it's powerful, and it's connected to the cloud. The board is powered by a Cypress Wi-Fi chip alongside a powerful STM32 ARM Cortex M3 microcontroller.[8] The tools that make up the Photon ecosystem (and come bundled with the board) are designed to let you build and create projects in any way you want. Count on firmware in our web or local IDE, deploy it over the air, and build your web and mobile apps with ParticleJS and our mobile SDK.[9] The Particle Photon is the core of the system, this will handle the interaction of all the sensors. The IoT Particle Photon device is shown in Figure 5.

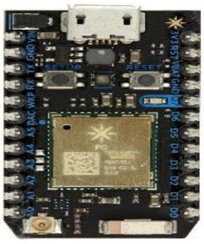

Figure 5: Particle Photon.

3 RESULTS AND DISCUSSION

3.1 RESULTS

Figure 6 displays the system integration. The DHT11 sensor, which is capable of measuring temperature and humidity, is connected to the digital pin D0 of the IoT Particle Photon device. The HC-SR sensor, which is utilized to detect object distance using sonar, is connected to both digital pin D6 and analog pin A0 of the IoT Particle Photon device, where the echo pin is connected to the digital pin and the trigger pin to the analog pin. This sensor measures the water level variable in the tank. The YF-S201 sensor, a Hall effect flow meter or water sensor, is connected to digital pin D4, which has an interruption protocol that simplifies the measurement. This sensor measures the water flow rate in liters per minute. The pump is connected to an activation relay, which is in turn connected to the digital pin D7. The high and low level indicator lights are connected to digital pins D2 and D3, respectively.

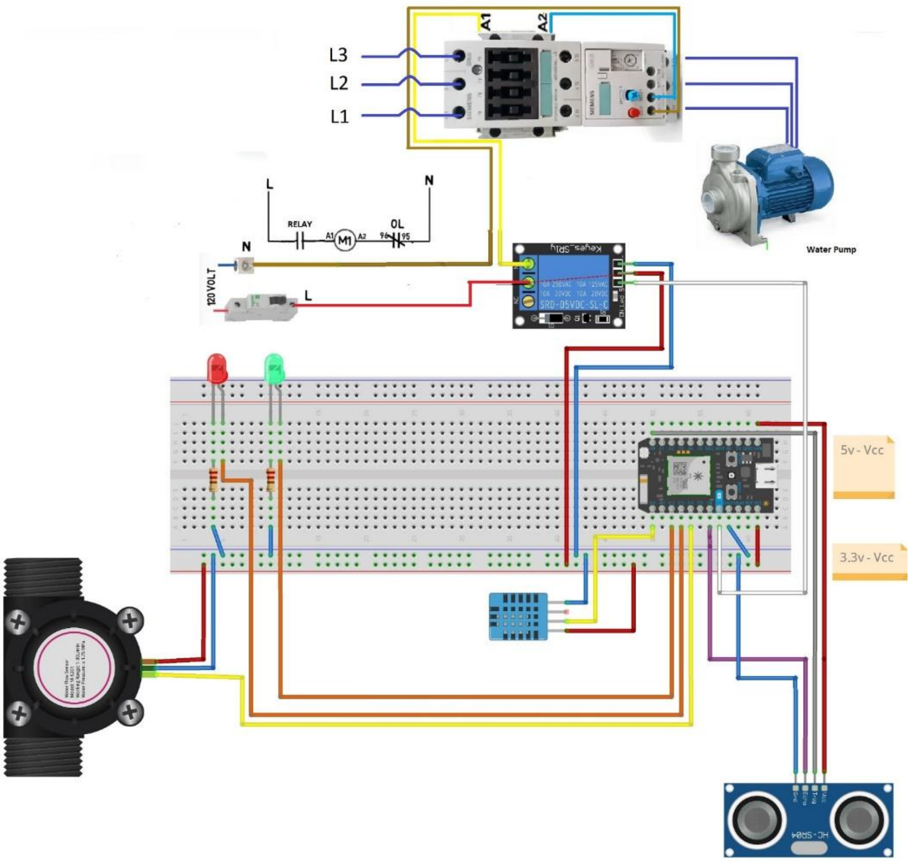

Figure 6: Diagram of components and electrical connections of the node.

Once the node was built and installed, readings were taken from the sensors at intervals of 1 day, obtaining real-time data on temperature, humidity, water level, and the flow generated by consumption in numerical format. The Particle Photon microcontroller collected the data obtained and sent it to a visualization platform, in this case Ubidots, and subsequently to a real-time database. Finally, the data were displayed to the end user in the form of graphs. With this, the objective of this project was achieved, which was to develop a node capable of measuring certain variables in a real-time water availability monitoring process to help the relevant authorities make accurate and quick decisions. Additionally, as a unique feature of this IoT node, whenever the water level in the tank was in a low state, the pump relay was activated to supply water, and when the water level in the tank was in a high state, the pump relay was deactivated.

In figure 7 shows the Real-time water level monitoring and Figure 8 shows the one day history.

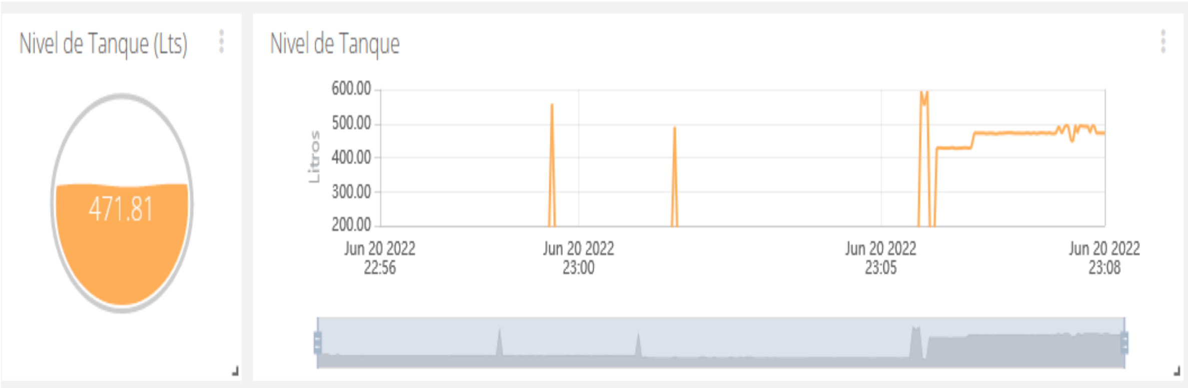

Figure 7: Real Time water Level graph, where the x-axis represents time in hours and the y-axis represents level in liters(lts).

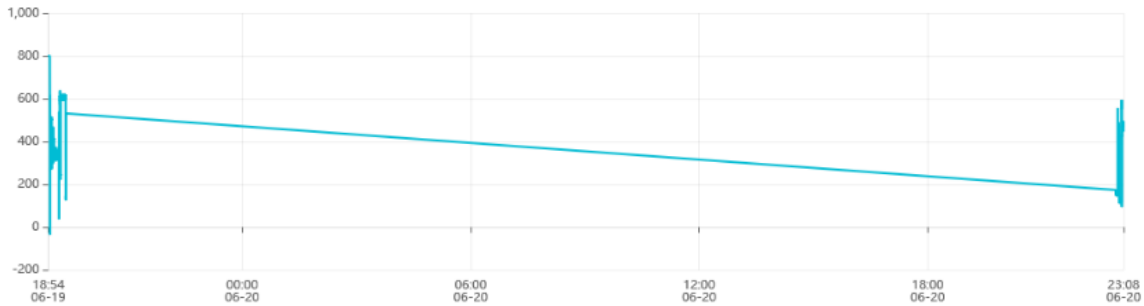

Figure 8: Water Level graph, where the x-axis represents time in hours and the y-axis represents level in liters(lts).

In Figure 9 is shown the Real-time humidity monitoring and Figure 10 shows the one-day history.

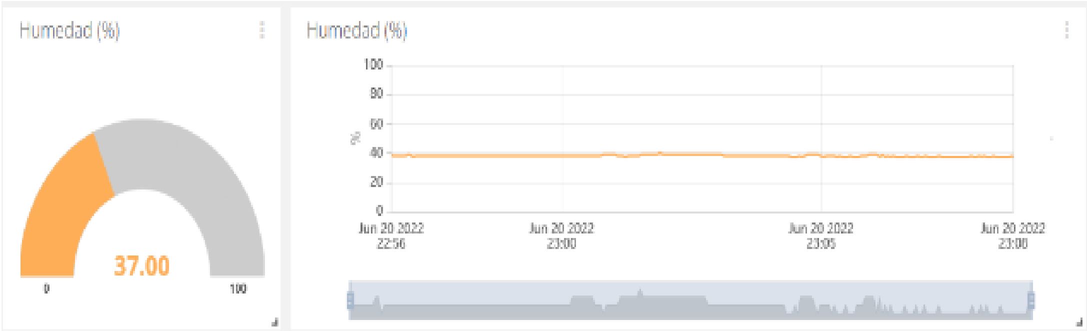

Figure 9: Real Time Humidity graph, where the x-axis represents the time in hours and the y-axis represents the percentage of relative humidity (%).

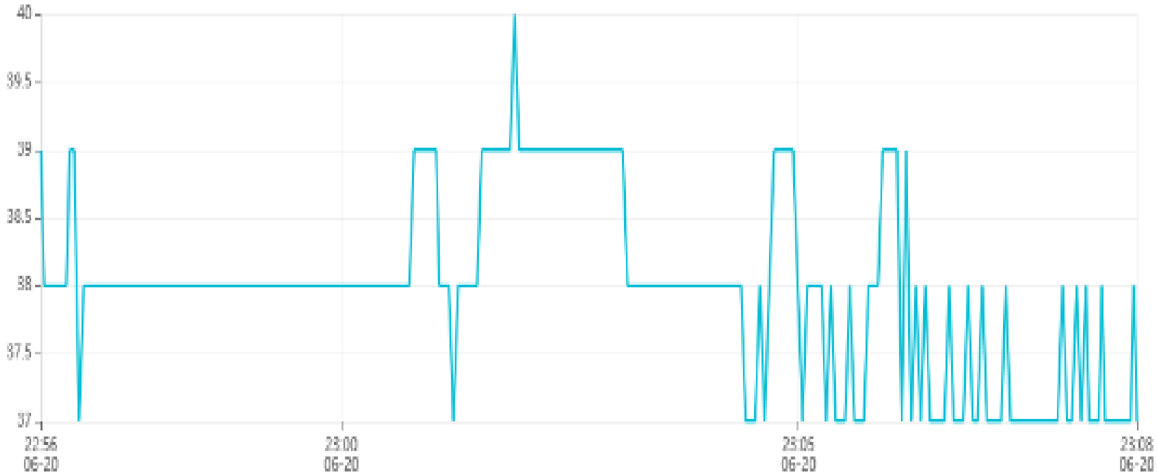

Figure 10: Humidity graph, where the x-axis represents the time in hours and the y-axis represents the percentage of relative humidity (%).

In Figure 11 is shown the Real-time temperature monitoring and Figure 12 shows the one-day history.

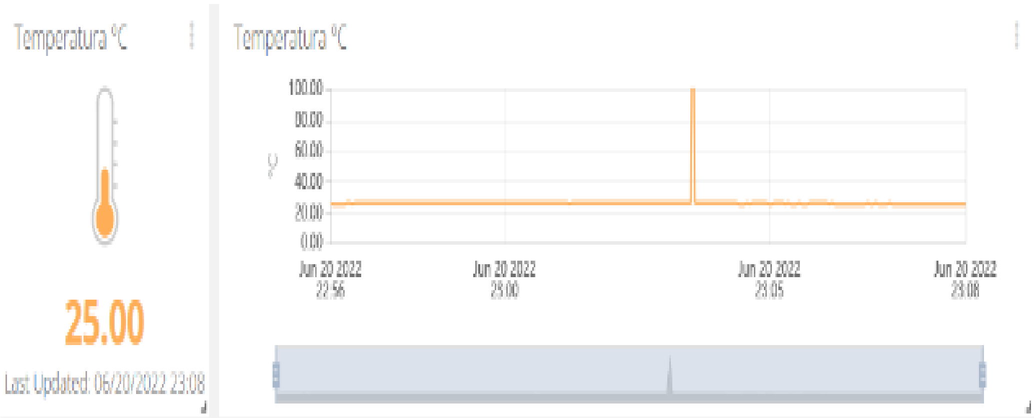

Figure 11: Real Time Temperature graph, where the x-axis represents the time in hours and the y-axis represents temperature in degrees Celsius(°C).

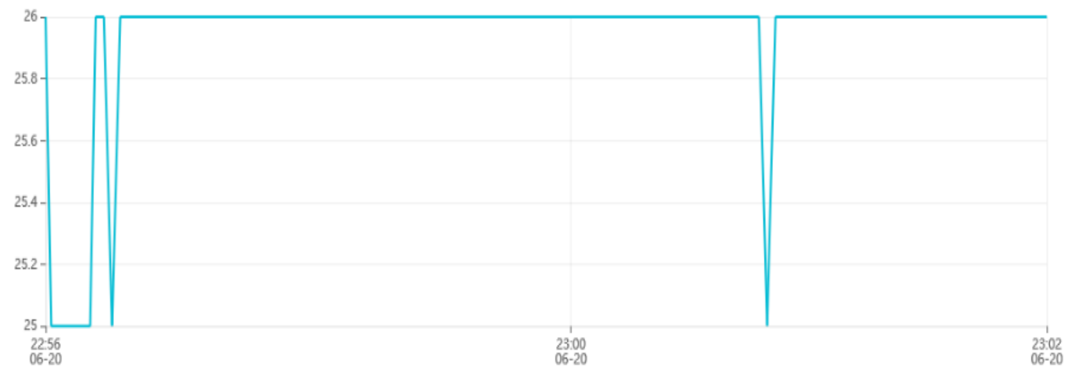

Figure 12: Temperature graph, where the x-axis represents the time in hours and the y-axis represents temperature in degrees Celsius(°C).

In Figure 13 is shown the real-time flow and figure 14 shows the one-day history.

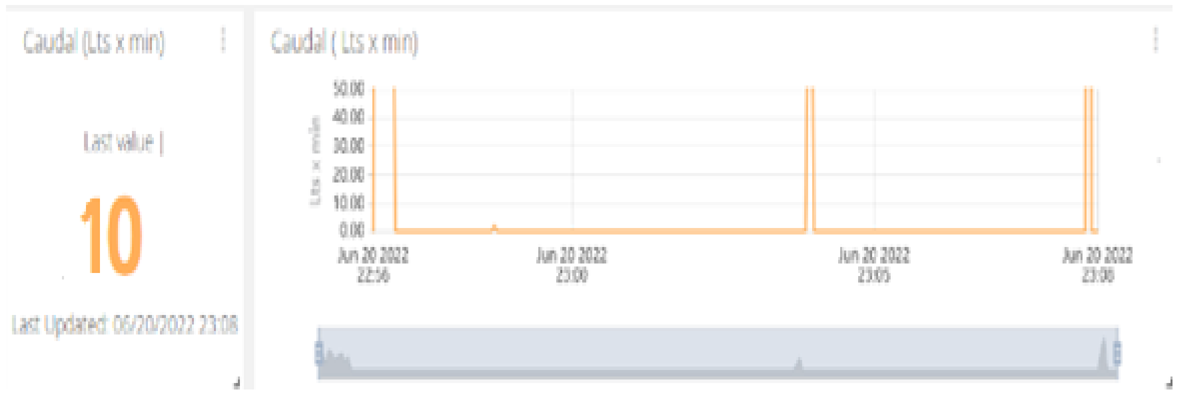

Figure 13: Real Time water flow graph, where the x-axis represents time in hours and the y-axis represents flow in liters per minute (lts x min).

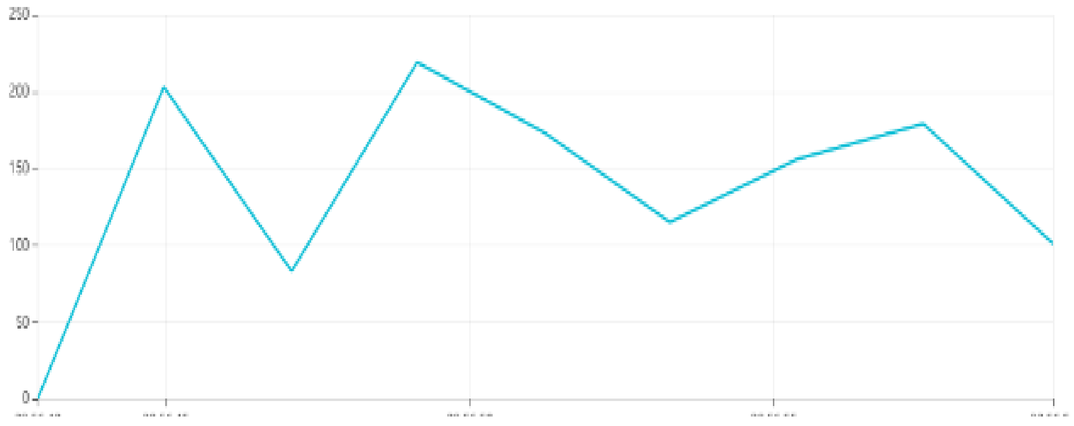

Figure 14: Water flow graph, where the x-axis represents time in hours and the y-axis represents flow in liters per minute (lts x min).

In Figure 15 is shown the web interface where the data was being worked with.

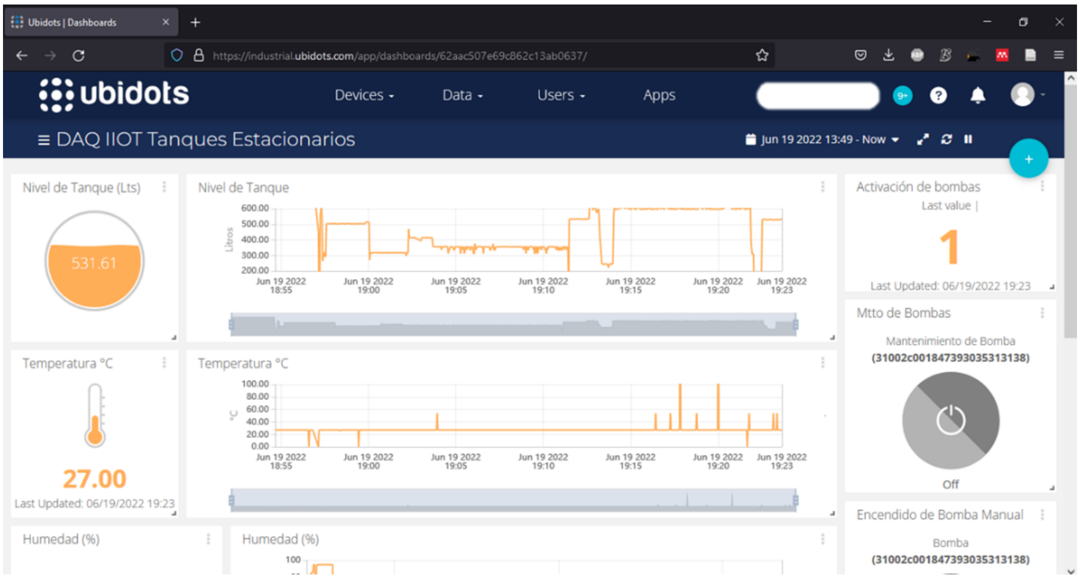

Figure 15: Ubidots Interface.

CONCLUSIONS

An IoT node was developed capable of monitoring in real time water level, temperature, relative humidity, and water flow. The data of the variables are stored in a database in real time and are graphed in real time in a web application which allows to visualize each one of the data so that the end user is alerted to each one of the variables.

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