

Journal Scientific and Applied Research, Vol. 31, 2026
International Journal

ISSN 1314-6289 (Print)
ISSN 2815-4622 (Online)

Original Contribution

IMPROVING THE RELIABILITY OF WATER TANK LEVEL CONTROL

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Abstract: *Water resources management has always been important, especially in the recent decades. Automatic methods for regulating tank levels have existed since ancient times; however, modern automatic control systems are completely different.*

A primary aim in industrial control is achieving maximum reliability at minimum cost. This article presents a method for regulating tank levels using various control devices (PLC, HMI, etc.), aiming to achieve superior control with a minimal number of components.

Key words: *Control system, Automatic level control, Water level Control, Automation, PLC, Float Switch.*

1. Introduction

Automatic tank level control systems can be implemented in various ways, but they all there are an almost identical block diagram (Fig.1).

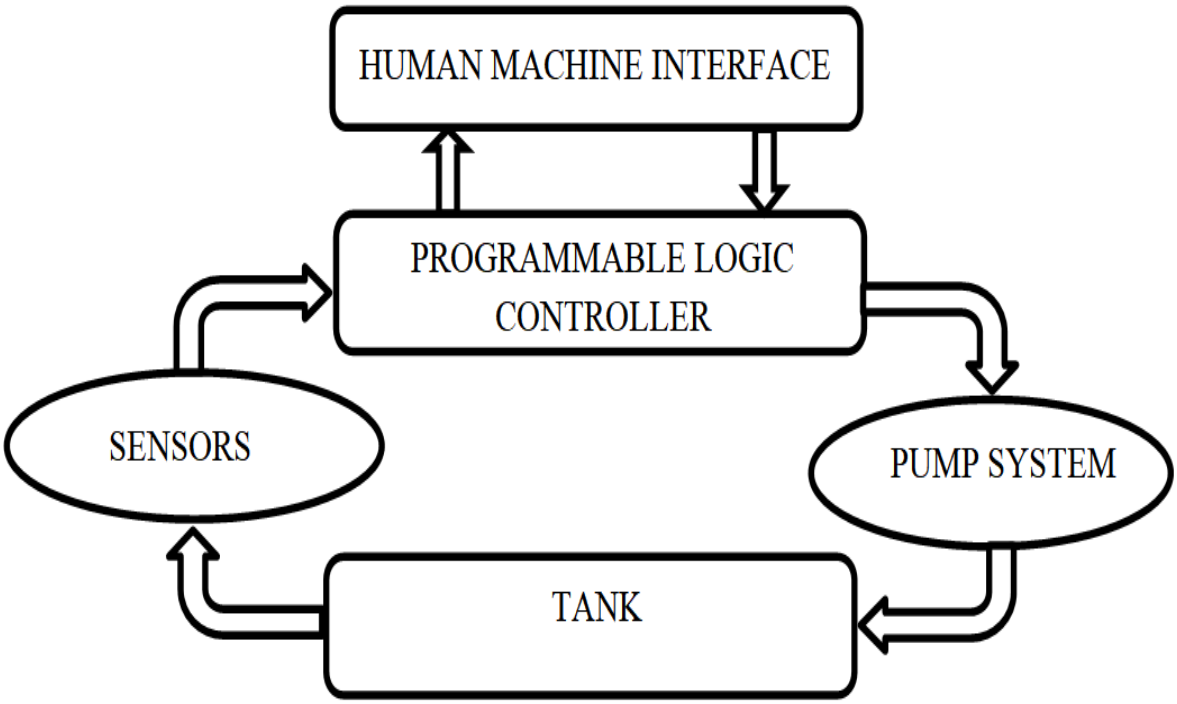


Fig. 1. Block diagram of an automatic tank level control system

The system consists of a human-machine interface (HMI), a programmable logic controller (PLC), sensors, and a pump system. The sensors transmit information about the controlled process to the PLC, and a control action for the pump system is generated based on the programmed algorithm and parameters set via the HMI. The sensors can be analog or digital, with the method of controlling the water level in the tank depending largely on the sensor type. The pump system can include one or more pumps, as well as various control configurations. Although tanks may vary significantly in shape, however, the key parameter is their volume.

2. Description of an automated level control system using two floats for high and low levels

Figure 2 illustrates one of the most commonly used scheme for tank level control, originating from the era of relay-contactor control systems. It operates the following way: when the water level drops below the lower sensor 1, the pump starts and runs until the water reaches sensor 2, then the pump shuts off; this cycle repeats indefinitely. The use of two sensors-one for the high level and one for the low level-creates the hysteresis required to start and stop the pump. However, this system has a significant drawback: a failure in a sensor causes the tank to either overflow or run empty.

Neither outcome is desirable, with overflow resulting in the loss of valuable water resources. The standard solution to this problem involves adding extra sensors for emergency low and emergency high levels. This approach doubles the number of sensors used, thereby reducing system reliability and increasing control costs.

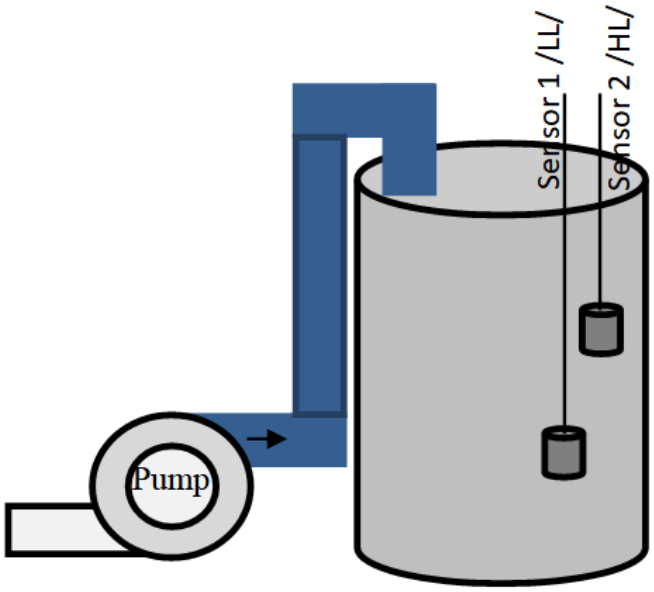


Fig. 2. Tank level control scheme with low and high level sensors

3. Improving the performance of the system under consideration

Figure 3 illustrates a variation of the control scheme discussed above, which achieves similar control, while eliminating the previously mentioned drawbacks. In this configuration, both sensors are positioned at the same level-specifically, the level corresponding to the "high level" in the previous scheme. Hysteresis is implemented via software, while the two sensors provide mutual redundancy. Figure 4 shows the control algorithm for sensors positioned at the same level.

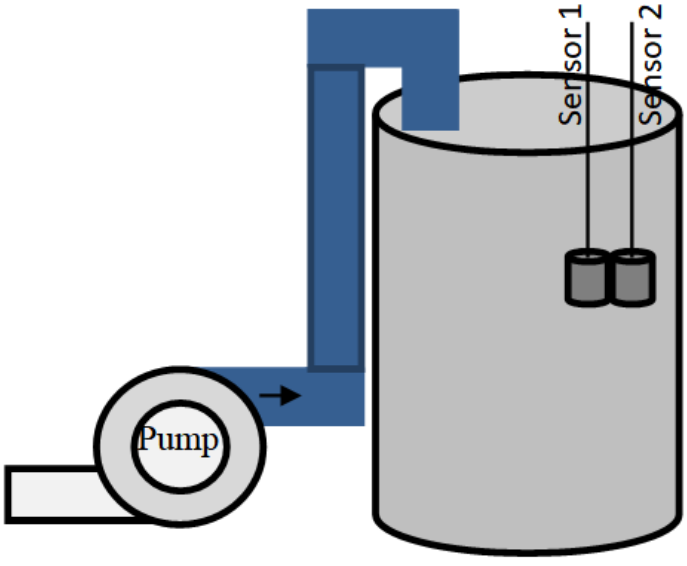


Fig. 3. Tank level control scheme with two sensors at the same level

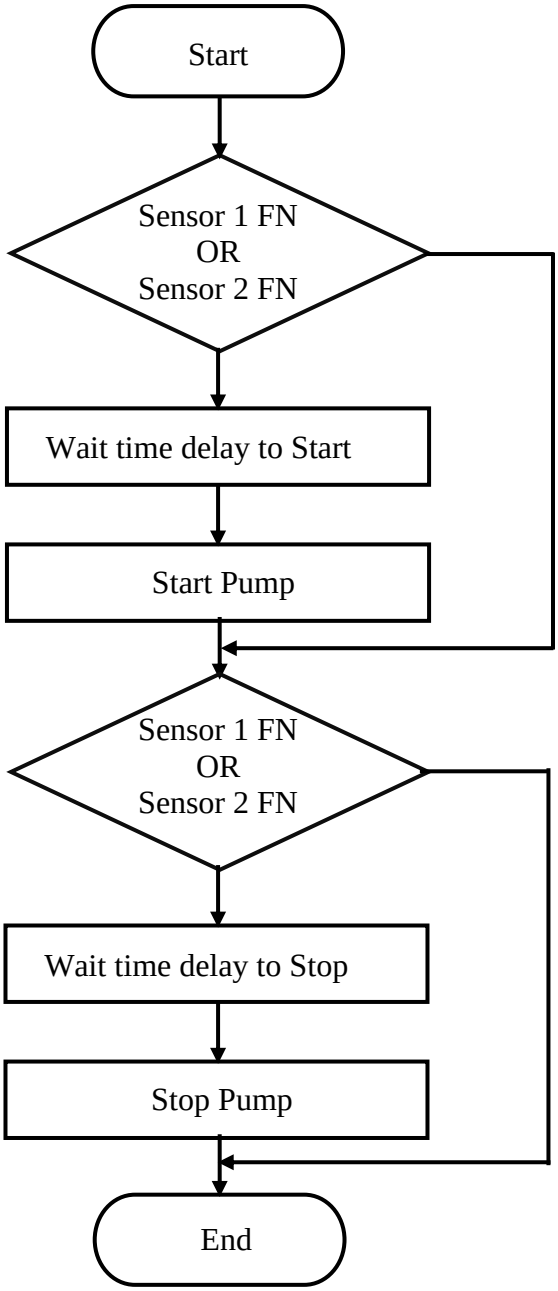


Fig. 4. Control algorithm using two sensors at the same level

When the signal from either of the two sensors changes from "1" to "0," a timer initiates a delay before the pump starts. This delay is determined empirically based on the tank's drainage characteristics; it accounts for the time required for the water level to drop to the approximate "low level" defined in the control scheme of Figure 2. If the level does not drop sufficiently to reach the "low level" threshold, it is not an issue; the pump will still start, and the tank will refill to the "high level" (the position of the sensors in Figure 3). The pre-start delay offers an additional benefit: it gives time for the second sensor to trigger as well as the water level continues to drop. The objective is to use the control algorithm to verify that both sensors aren’t activated during the tank's drainage process. This makes it possible to determine if one of them is faulty and has remained triggered due to electrical or mechanical issues. A message is generated if a faulty sensor is detected. The algorithm described above

will continue to operate using only a single sensor (in the event of a failure) until the fault is rectified.

Once the pump starts, the program algorithm monitors whether the signal from either of the two sensors changes from "0" to "1". Upon such a change, a timer initiates a delay before the pump stops. This time delay ensures the tank fills sufficiently to fully submerge-and thus activate-both sensors. This is also necessary if the tank is open, in order to protect the sensors from dust and debris. In such a case, a programmed algorithm can verify whether both sensors have been activated. This allows for the detection of a faulty sensor and the generation of a corresponding message. The described algorithm will continue to function using a single sensor in the event of a failure, thereby allowing time for the defective sensor to be replaced.

5. Software implementation of the discussed improved level control scheme

A program based on the algorithm shown in Fig. 4 was created using Siemens LOGO! Soft Comfort software. It is written in the Function Block Diagram language, one of the languages used to program the Siemens LOGO! controller.

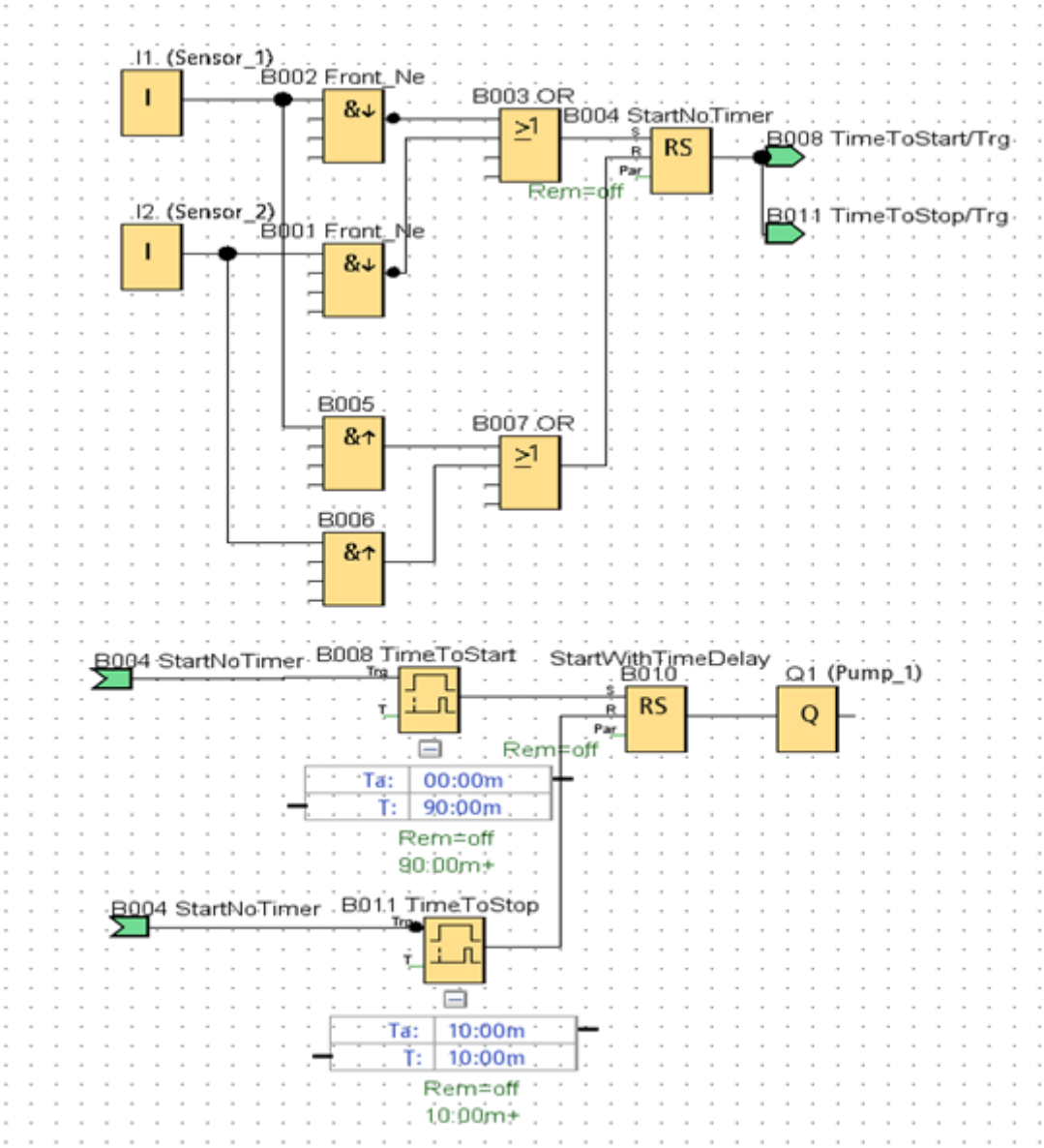


Fig. 5. Program written in the Function Block Diagram language

In addition to the described control method - implemented using modern control technology - counters for tracking the number of activations or operating hours of individual components can easily be added. This information can facilitate control system maintenance by allowing for the replacement of components that have reached the end of their manufacturer-specified service life.

Conclusions

1. Classic systems for water level control with two sensors for high and low water level have a significant drawback.
2. The usage of classic systems for tank level control can cause significant loss of water resources.
3. The drawbacks of the "classic" scheme can be overcome with a software solution.
4. Care for the environment is provided by using less natural resources.

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