Journal of Electrical Engineering and Automation (ISSN: 2582-3051)
www.irojournals.com/iroeea/

Flow rate Controlled Water Sprinkler using myRIO controller and LabVIEW

Harsha Govindray Vernekar[1], C. M. Maheshan[2]

[1]PG Scholar (Control and Instrumentation), Department of Electrical Engineering, University Visvesvaraya College of Engineering, Bengaluru, Karnataka, India
[2]Associate Professor, Department of Electrical Engineering, University Visvesvaraya College of Engineering, Bengaluru, Karnataka, India

E-mail: [1]harshavernekar123@gmail.com, [2]mcm_eeuvce@bub.ernet.in

Abstract

Agriculture is an important component of the primary sector and is also used to develop both secondary and tertiary sectors of the economy. Therefore, agriculture is the backbone of India. Farmers suffer from various problems like debts, crop failure, mental health, technology, water problems, etc. A system has been proposed in this paper to improve farming in a sustainable method using the existing technology. Flow rate -controlled water sprinkler using a PID controller which is executed using NI LabVIEW and a interfacing device NI myRIO, has been designed. NI LabVIEW is a graphical programming tool for validation and resolving system. Sensors like the rain sensor and moisture sensor are interfaced with NI LabVIEW, with the help of NI myRIO. A flow sensor is interfaced with NI myRIO through a UART connection. Sprinkling of water to the crops based on the requirement of the soil has been accomplished using this proposed system.

Keywords: PID controller, NI LabVIEW, Sensors, Flow rate Controller, NI myRIO

1. Introduction

The flow rate -controlled water sprinkler method is widely used for irrigation nowadays. There are different types of irrigation. Sprinkler irrigation is the type of irrigation that is often used. Providing required amount of water to plants is the basic principle of irrigation [2]. There are many types of irrigation systems such as Surface Irrigation, Lateral Irrigation, Center Pivot Irrigation, Localized Irrigation, Lateral Move Irrigation, Sub Irrigation, and Manual Irrigation [3]. For a flow rate -controlled water sprinkler project, LabVIEW is used for easy programming and to get correct sensor values [1].

DOI: https://doi.org/10.36548/jeea.2022.4.006
Received: 19.10.2022, received in revised form: 26.11.2022, accepted: 12.12.2022, published: 24.12.2022

In sprinkler irrigation systems, water is emitted to an area with a required fixed radius. Using sprinklers, water can be emitted using a wider radius. Water pressure of the sprinkler varies based on the speed of the water pump. Through sprinklers, water is spread into the air, and then breaks into small water droplets. There are two types of sprinklers namely, gear drive and impact sprinklers. Gear drive sprinklers spread water in the region with uniform distribution at all times, produced by nozzle sprays and streams of water. Whereas the impact sprinklers can be adjusted to cover only a part of the circle. In these methods, the wastage of water is more; because, when there is already sufficient water content present in the soil, the water sprinkled may be excess. To avoid this wastage of water, checking the moisture content in the soil is necessary [4]. Based on the moisture content in the soil, the motor can be turned on or off using PID controllers. Normal method of sprinkler irrigation is the distribution of water by pumping through pipes [5]. In this work, a prototype of a flow rate-controlled water sprinkler has been designed. Sprinkler irrigation control is performed using rain sensor, soil moisture sensor, and flow sensor. PID controller technique is used for controlling the speed of the motor, which is useful in the control system of the process. It has a feedback which follows the mechanism of control loop.

Error value calculated by the PID controller is the set point and the process variable difference, and correction is applied depending on different terms [8]. Usage of this technique in practice is by automatically applying responsive and accurate correction. The proportional term indicated by P is the present value of error obtained as the set point and process variable difference. By using proportional gain, error obtained is proportional to control output. Usage of proportional control individually results in error because an error is required by controller to generate proportional output response [9]. The past value of the error is the integral term which is integrated over time. Integral term eliminates the error obtained by the usage of proportional control by adding the effect of controlling, due to the error of cumulative value. Integral term increases as the error is reduced, and the effect of proportion decreases. For estimating the future values of error, the derivative term is used as the rate of change of current value. For reducing the error value, rate of change of error is used. Tuning is used to maintain the effect and give normal control function [10].

2. Design of water flow sensor

Flow sensor used in the project is YF-S201. It requires a input voltage of 5V and draws a maximum of 15-20mA. The flow rates can be calculated in many methods like changes in velocity or kinetic energy. As the cross-section of the pipe is same, and the average velocity indicates of rate of flow, hence the formula used to determine the flow rate is,

$$Q=V*A \tag{1}$$

Where, Q= Flow Rate of the water through a pipe

V=Average Velocity of fluid

A= Area of the cross-section of a pipe

From the datasheet, it is found that,

$$\text{Sensor Frequency (Hz)} = 7.5*Q \text{ (litres / min)} \tag{2}$$

$$\text{Litres} = Q * \text{time elapsed (second)} / 60\text{(seconds / min)} \tag{3}$$

$$\text{Litres} = (\text{Frequency (Pulses / second)} / 7.5) * \text{time elapsed (seconds)}/60 \tag{4}$$

$$\text{Litres} = \text{Pulses} / (7.5 * 60) \tag{5}$$

Data collected by Arduino is communicated to myRIO through a UART connection connected to pin 10 [6]. Flow sensor has 3 pins Ground, Vcc and Input. Flow sensor connection to Arduino is shown in Figure 1.

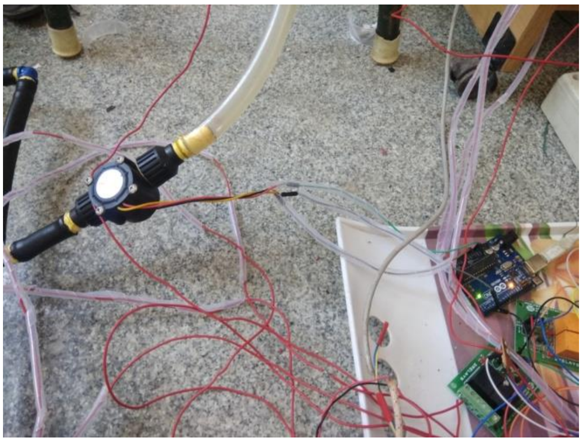

Figure 1. Flow Sensor

3. Proposed Work

The block diagram of the flow rate-controlled water sprinkler is shown in Figure 2. The control method is the PID controller. Moisture sensor used in the setup acts as the feedback signal for controller. The speed of the motor is calculated by the control unit. Wheat and Maize plants are used in the setup. To produce wheat of around 1kg, the water required by the crop is around 500-4000 litres. For a well-grown maize plant, the water required is around 2-3 litres. In this setup, there are a total of 2 lateral pipes, and each lateral pipe has 1 sprinkler controlled by a solenoid valve. One sprinkler is set up in a tub where a wheat plant is grown and another sprinkler is set up in a tub where a maize plant is grown. The distance between the lateral is 40cm. The height of the sprinkler above the pipe is 6.5cm.

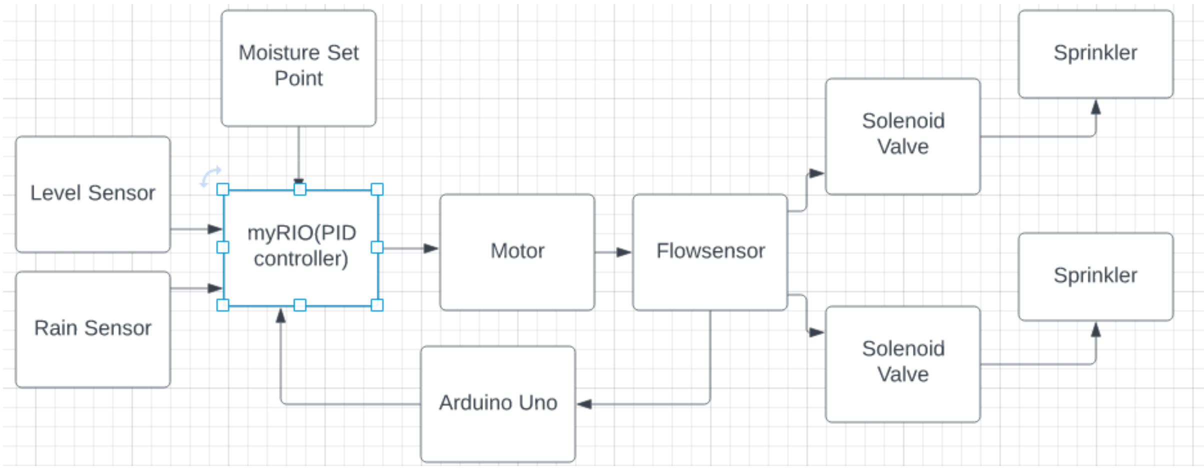

Figure 2. Block diagram of the proposed flow rate-controlled water sprinkler

As shown in the above figure, myRIO controller has 3 inputs such as level sensor, rain sensor, moisture sensor. The output connections are motor and solenoid valve. The flow rate of the flow sensor is measured using Arduino Uno which is then connected to myRIO controller. Two sprinklers are connected to two solenoid valves. All these procedures are implemented on myRIO, which is an embedded evaluation board made by National Instruments.

The LabVIEW interface for the proposed design is shown in Figure 3. According to Figure 3, there is one analog input and three digital inputs. PID controller gets the set point value and process variable value through moisture sensor output. The output of the PID controller is connected to PWM block through which duty cycle is measured. The output of the Arduino Uno is connected to myRIO through UART connection.

UART consists of two parts transmitting UART and receiving UART. It allows parallel communication between microcontrollers, CPU, memory etc., and the water supply to the two fields is controlled by the solenoid valve which is connected at the other end of the flow sensor. This hardware setup is shown in Figure 4. Two tanks are used in the setup.

Whenever the level of the water in the above tank is below the low level, then water is pumped from the below tank until the water reaches the high level [7]. When the moisture content in the soil is below the set point, then the motor is turned on. As the moisture value changes the speed of the motor is also adjusted depending on the PID controller [12]. The motor used in the setup connected to the sprinkler is WDB-38F with a voltage supply of 12vDC and power of 1.6W [11].

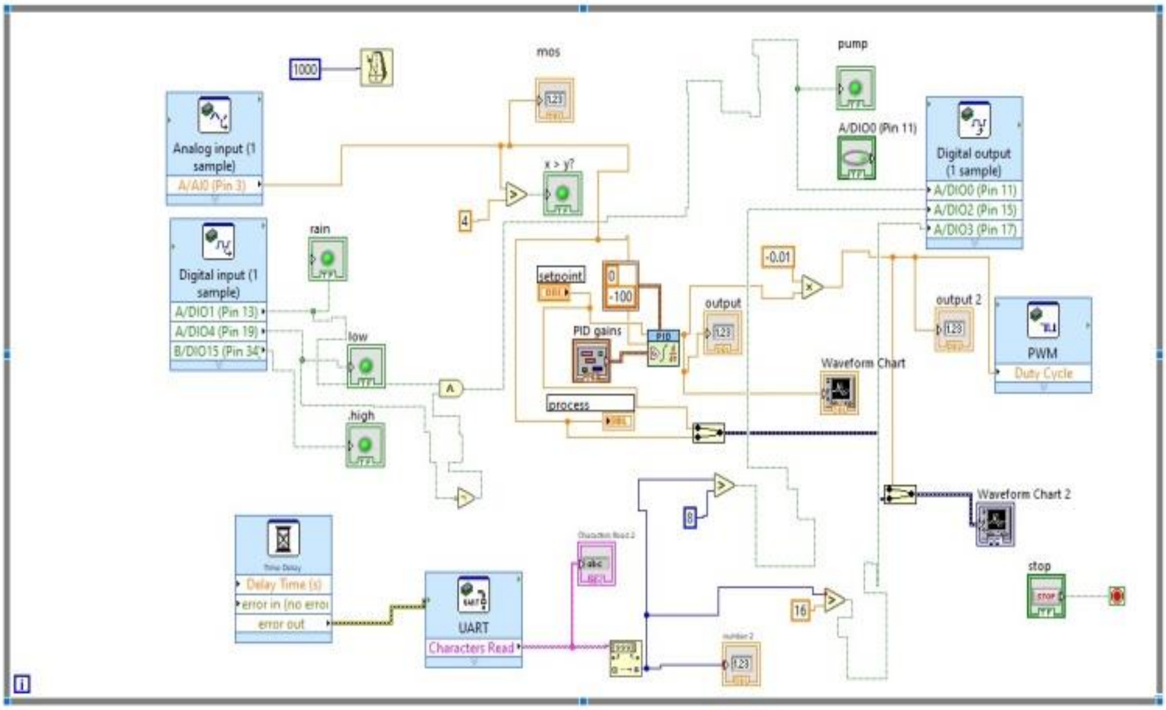

Figure 3. Block diagram of LabVIEW interfaced

The complete prototype of project done is shown in Figure 4. Different modules are used in the project such as the two tanks. The bottom tank indicates the sump or well, and the top tank is used to store water which is later used for irrigation. Two submersible pumps are used. One is used in sprinklers and the other is used to fill the tank [13]. Controller used is LabVIEW myRIO. Arduino is used to receive the flow sensor readings and then transmit it to myRIO using UART connection. Rain sensor is used to check the presence of rain. The speed of motor is controlled by PID controller with moisture sensor as the feedback. Motor driver is used to supply large power to the motor using very less voltage signal from a control system.

In the system, the control method used is the Proportional Integral Derivative (PID). It gets a feedback signal from moisture sensor and actuator as pump. Figure 5 shows the block diagram of PID controller. PID controller gets input as error, where error is equal to the difference between set point and process variable.

Figure 4. Prototype of the complete project
(Power supply is indicated by (1) , myRIO is indicated by (2), rain sensor is indicated by (3), (4) indicates rain sensor Arduino Uno, (5) indicates 2 channel 12v relay, flow sensor is indicated by (6), (7) indicates solenoid valve, (8) indicates sprinkler, (9) indicates moisture sensor, (10) indicates bottom tank, (11) indicates top tank, (12) indicates motor, and (13) indicates level sensor.)

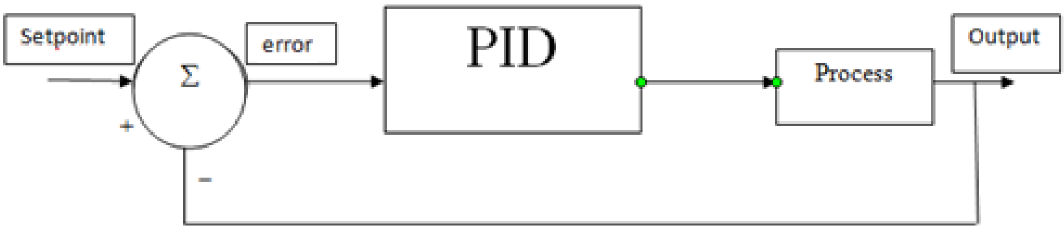

Figure 5. Block diagram of PID controller

PID controller method can be expressed by the following equation,

$$u(t) = Kp\ e(t) + Ki \int e(t)dt + Kp\ de/dt \tag{6}$$

where, u (t) = PID control variable; Ki = integral gain; Kp = proportional gain; de = change in the error value; e(t) = error value; dt = change in time.

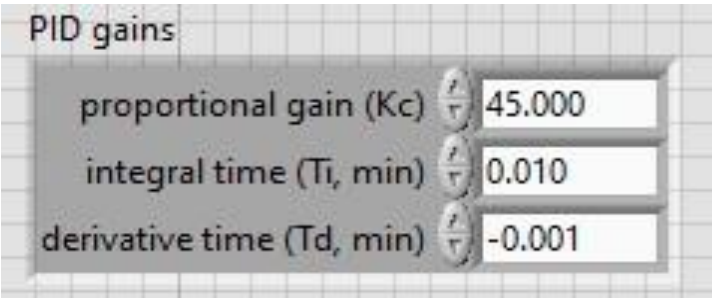

Figure 6. PID gains

PID gains value selected is mentioned as shown in Figure 6. Proportional gain value selected is 45, Integral time value is 0.010 and Derivative time is -0.001.

4. Results and Discussion

The prototype of a flow rate-controlled water sprinkler has been designed. The system has been tested for two crops namely wheat and maize. When there is no moisture content in the soil i.e., when the moisture level is above 4, the motor turns on and hence the sprinklers. The waveform of this particular condition is shown in Figure 7. Similarly, when the moisture content is present in the soil then based on the values of set point and the values of process variable, the speed of the motor reduces gradually and then the motor turns off. The waveform of this particular condition is observed in Figure 8. From this, it is observed that the control system maintains the flow rate of water according to its set point and process variable.

The proposed system is a cost-efficient method when compared to the previous method, because there is a lot of crop spoilage in the previous method due to the supply of more water than the required amount of water. The results of this project are shown in the following tables. According to Table 1, to grow wheat crop, it requires around 600-800 mm of water, and for maize crop, it requires around 400-500 mm of water. According to Table 2, the flow rate at the low level of the tank is 3 litre /minute and at high level is 1 litre /min. And from Table 3, it is observed that the moisture sensor value is greater than 4 for dry soil and less than 4 for wet soil. When there is no moisture content in the soil, the set point value will be constant as the value set is 1.42, and moisture sensor value is 4.85. This is shown in Figure

7, and when there is a moisture content in the soil, the process variable value drops to 1.3 and similarly it will be constant to nullify the error which is shown in Figure 8.

Table 1. Water requirement by the crop

Crops	Water requirement for a crop (mm)	Water requirement in a day (litres)
Wheat	600-800	1-2
Maize	400-500	2-3

Table 2. Flow rate at different levels

Level	Flow rate (lit/min)	Flow rate (lit/hr)
Low level	3	180
High level	1	60

Table 3. Moisture content in the soil

Moisture Value	Moisture content
Greater than 4	Dry soil
Less than 4	Wet soil

Figure 7. Output Waveform when there is no moisture content in the soil

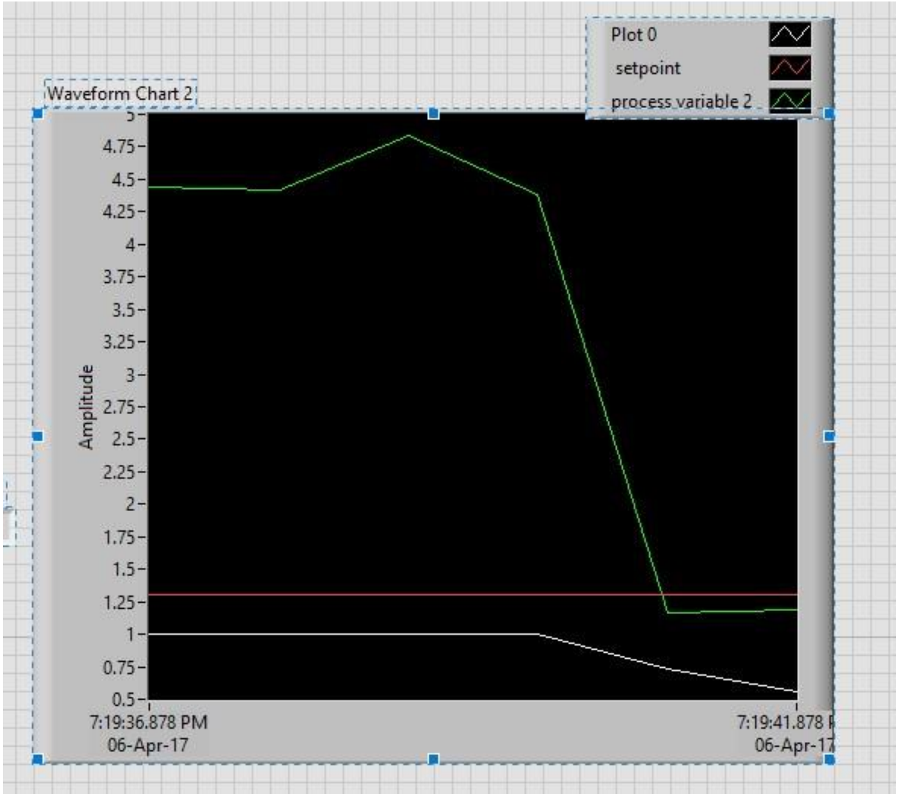

Figure 8. Output Waveform when there is moisture content in the soil

5. Conclusion

When using a normal sprinkler irrigation method, there is continuous sprinkling of water without checking the requirement by the soil. Hence, there is a lot of wastage of water and crop in this method. To avoid such wastages, the prototype of a flow rate-controlled water sprinkler is designed in this paper. By studying the requirement of water by the crop, the appropriate flow rate of water is provided to that particular area where the crops are growing. That flow of water is controlled by the solenoid valve. When the level of water of the above tank reduces than the required value, water is pumped from the bottom tank. When the moisture content in the soil is greater than 4, then according to the moisture set point value, the motor speed is controlled. Thus, the flow rate of water is controlled using a PID controller.

References

[1] Ch.Narendra Kumar, M.Pradeep, N.Rajeswaran, T.SamrajLwarence, "Sensor-Based Smart Monitoring and Controlling System for Cultivation using LabVIEW, "International Journal of Innovative Technology and Exploring Engineering(IJITEE), Volume -8 Issue-11, September 2019.

[2] Suwito, M Ashari, Muhammad Rivai, Muh.Anis Mustaghfirin, "Implementation of Water Pressure control on drip irrigation systems using a centrifugal water pump driven by a brushless DC motor," AIP conference, October 2018.

[3] M.N. Gogoi, "An automated garden irrigation system: Controlled and monitored via Arduino and LabVIEW", International Journal of Computer Science and Engineering, Volume -6 Issue -5, May 2018.

[4] G. Ravi Kumar, T.Venu Gopal, V.Sridhar, G. Nagendra, "Smart Irrigation System", International Journal of Pure and Applied Mathematics, Volume-119 ano.15 2018, 1155-1168.

[5] Punitha K, Shivaraj, Sudharshan Gowda, Devarajnayaka R, JagadeeshKumar H B, "Automated Plant Watering System", International Journal Of Engineering Research and Technology, Volume -5 Issue-18, 2017.

[6] P S Aswale, Sonal Sali, "Automatic Irrigation Control System based on LabVIEW Arduino Interfacing" International Journal of Innovative Research inTechnology, Volume 2 Issue 12,2016.

[7] Pillalamarri Madhavi, B.Aarthi, "Automated Irrigation System Using PLC", International Journal of Creative Research Thoughts, Volume 8 Issue 6, 2020.

[8] R. Jafari , S. Razvarz, C. Vargas - Jarillo ,"Control of Flow Rate in Pipeline Using PID controller" , International Conference on Networking ,Sensing and Control , 2019.

[9] Kiam Heong Ang , G. Chong and Yun Li, "PID control system analysis, design and technology", IEEE Transactions on Control Systems Technology, Volume 13, no. 4, 2005.

[10] P.V. Gopi Krishna Rao , M.V. Subrmanyam , " Study on PID controller design and performance based on tuning techniques", International Conference on Control, Instrumentation, Communication and Computational Technologies, 2014.

[11] G. Rata, C. Bejenar and M. Rata, "A Solution for Studying the DC motor control using NI MYRIO-1900', International Conference on Modern Power Systems,2019.

[12] P .M. Lingom , J. Song-Manguelle, M.L.Doumbia, "Electrical Submersible Pumps: A System Modelling Approach for Power Quality Analysis With Variable Frequency Drives", IEEE Transactions on Power Electronics, Volume 37, No. 37,June 2022.

[13] Rakshitha M R , C M Maheshan, "A Review on Water Level and Quality Monitoring System", International Journal of Engineering Research and Technology, Volume 8,Issue 14, 2020.