

Customized Agricultural Automation

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ABSTRACT: Agriculture is the practice or the methodology involved in cultivating crops, raising sheep, cattle, poultry, etc to meet the daily increasing needs of the world's growing population. Out of these, cultivation is the most important process as the very existence of humanity depends on it. Automating such a process will reduce scarcity and will increase production. In this paper we are trying to automate the drip irrigation process, fertigation process, pesticide sprinkling process and the filter clog removal process. Drip irrigation is the process by which we irrigate the fields using drip tubes or nozzles to administer water in drops to the plants. This is done to reduce the wastage of water thus overcoming the problem of scanty rainfall.

KEYWORDS: Dripirrigation, fertigation, pesticide spraying, soil moisture sensor, atmospheric humidity sensor, variable frequency drives, solenoid valves, etc

I. INTRODUCTION

Modern agriculture requires field machinery capable of precise, repeatable operations based on models of systems and processes. In the mechatronics design process, applied to three examples, the efficiency of the design process and the performance of the mechanisms can be improved considerably through concurrent, integrated development. Such advanced systems with modern feedback controllers can generate significant demands for data processing and require substantial communications bandwidth. Standardized agricultural bus systems form the backbone for the high variability and high-bandwidth data streams. In the first example, the problem of mechanical grain yield sensors placed on combines, is described. By minimizing the influence of the friction of the grain kernels on the sensor, the total number of calibrations can be limited to once per harvesting season, independent of the condition and type of crop harvested. Targeted spraying requires an integrated adaptation of field-spraying machines on three levels: the equipping of a spray boom with optical sensors for weed detection, the stabilization of the spray boom to ensure correct location of the spray nozzles on the target after optical detection, and the improvement of the dynamics of the spray equipment hydraulics for fast and correct release of the prescribed dose. Uniform, accurate has high relevance for crops and the environment. To avoid nitrogen losses to the air (ammonia volatilization), spreading of liquid manure should be carried out very close to the soil (e.g., by trailing feet) and applied to the plants according to actual demand. A control system, based on an extended Kalman filter and Smith predictor, is developed allowing spatially variable dosing for the application flow rate. Communications networking of production units has become an important feature of agricultural production processes and can be expected to continue to grow. A standardized communication system serves as the backbone for precision agriculture.

"**Precision agriculture**" means that the production processes must be strictly controlled according to the demands of plants, soil, and environment in a site-specific way. The area of these sites is much smaller than the area of whole fields. For intensive cultures, such as vegetables, a site may even be only one plant. For animal production, this means that each animal is treated individually. Such a site-specific treatment requires the transmission of great amounts of data, such as individual values for references, states, and controlled variables, together with information about weather conditions, date, time, and location.

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Additionally, technical equipment and production processes should be upgraded with new knowledge, improvements, and enhancements in a simple and compatible way. Furthermore, maintenance and service of modern machines and process equipment should be handled according to their actual wear, operation times and circumstances. This necessitates sampling, transmission, and processing of data in a compatible way, since the data may be generated, transmitted, and processed in different units. In summary, compatible data transmission is a necessary condition for achievement of all the aims formulated above. Communication technology thus serves as the backbone of precision agriculture. In the following, we give three examples for advanced precision agriculture components: combine harvester, sprayer, and fertilizer spreader. This will be followed by a description of the "backbone" communication, which is organized in the form of a specific agricultural bus system and protocol.

Spatial variability in soil conditions such as texture, structure, soil moisture, and soil fertility give rise to local variations in crop yield. Although the lack of spatial uniformity of the factors that influence the growth of field crops, and hence their productivity, has been known and appreciated since early times, agricultural practice hardly takes into account this spatial variability in traditional arable crop production. The recent availability of reliable, inexpensive, and precise systems for on-the-go acquisition of the world position of soil tillage tools, machines for crop protection, fertilizers and harvesters during field operation (the Global Positioning System, or GPS, supported by dead reckoning systems), and parallel advances in sensor technology, precision mechanisms, and the information processing power of computers, have led to adoption of the concepts of precision agriculture, site-specific farming, or spatially variable application.

Here the process is divided into 4 sections where we will be automating the drip irrigation process through soil moisture and atmospheric humidity sensor and automating the fertigation process through the usage of timers. The pesticide sprinkling process can be initiated by means of a switch and the clog removal circuit can be actuated with the help of a pressure sensor.

II. RELATED WORK

By the term automation we mean that the process is to take place automatically and for this we had conducted a study regarding the variables that can be used to automate the process. After going through several possibilities and methodologies we zeroed down on the following sensors,

1. Soil Moisture sensor
2. Atmospheric Humidity sensor
3. Pressure switch

The **soil moisture sensor** used here is the gypsum block sensor which based on the electrical resistivity will measure the moisture content of the soil. The readings are scaled in such a way that when the resistance is high the soil moisture is low and if the resistivity is low the soil moisture is high.

The **atmospheric humidity sensor** relying on capacitance principle consists of a hygroscopic dielectric material sandwiched between a pair of electrodes forming a small capacitor. Most capacitive sensors use a plastic or polymer as the dielectric material, with a typical dielectric constant ranging from 2 to 15. In absence of moisture, the dielectric constant of the hygroscopic dielectric material and the sensor geometry determine the value of capacitance. At normal room temperature, the dielectric constant of water vapour has a value of about 80, a value much larger than the constant of the sensor dielectric material. Therefore, absorption of water vapour by the sensor results in an increase in sensor capacitance. At equilibrium conditions, the amount of moisture present in a hygroscopic material depends on both the ambient temperature and the ambient water vapour pressure. This is true also for the hygroscopic dielectric material used on the sensor. By definition, relative humidity is a function of both the ambient temperature and water vapour pressure. Therefore there is a relationship between relative humidity, the amount of moisture present in the sensor, and sensor capacitance. This relationship governs the operation of a capacitive humidity instrument. Figure 1 shows the basic structure of capacitive humidity sensor.

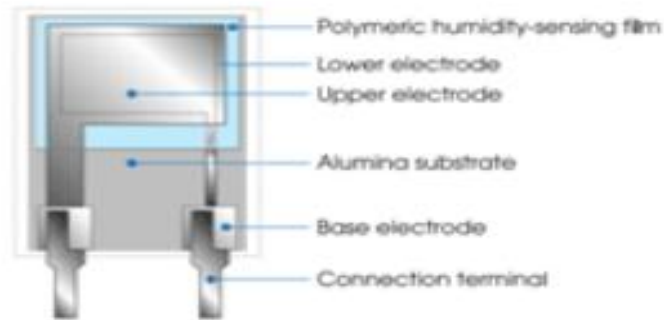


Figure 1: Basic structure of capacitive humidity sensor

Pressure switches are typically contact switches, meaning they fit into a container of liquid to measure pressure. Because most units are very small, the displacement of the unit is factored into the measurement. The unit is composed of two sections—the transducer unit and the switch unit. The transducer is the piece of equipment that measures the pressure in the container, and can be set to identify ascending pressure, descending pressure, or, in some models, multiple pressure points. When the set pressure is met, the transducer sends a signal to the switch unit, which converts that message into electrical energy. This energy triggers the next step in the application. Here below in Figure 2 are the soil moisture sensor, atmospheric humidity sensor and pressure switch used.

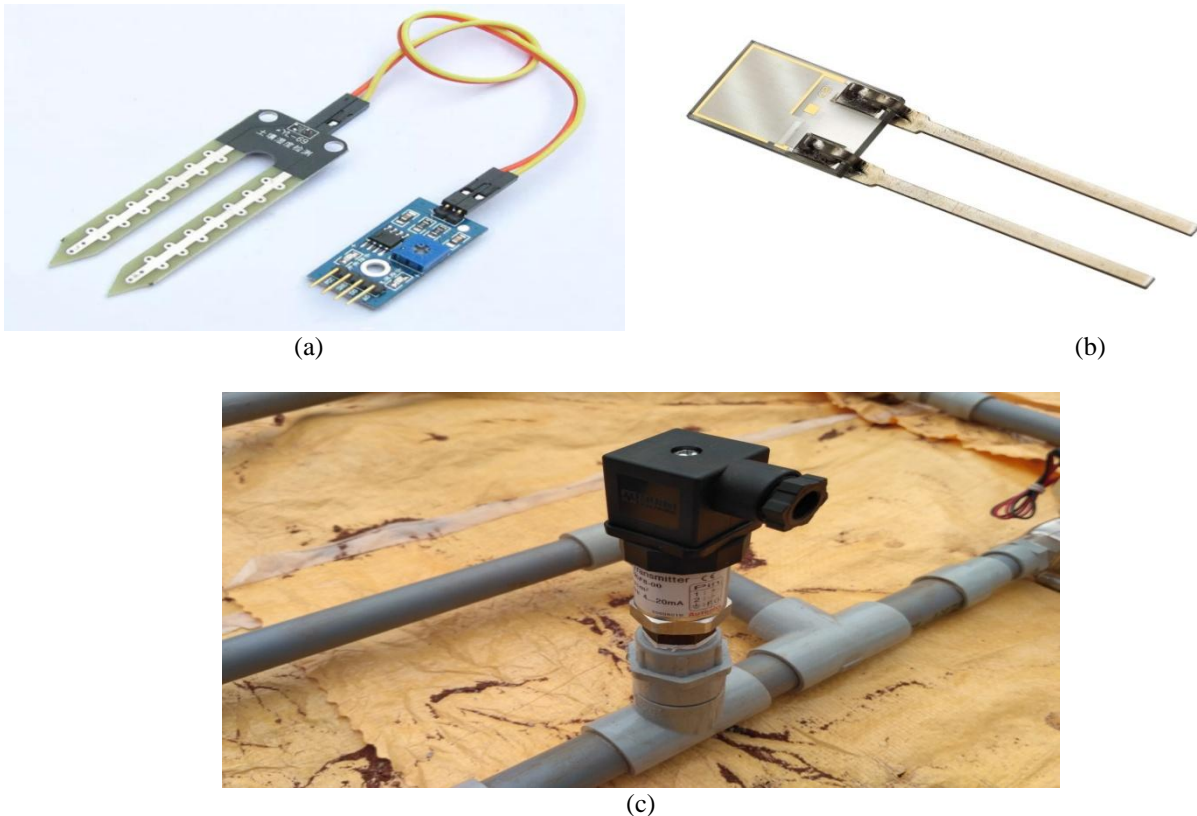


Figure 2: (a) Soil Moisture sensor (b) Atmospheric Humidity sensor (c) Pressure switch

Apart from these we conducted a study on the type of controller that can be used for this proposed automation. After going through several possibilities we settled at Programmable Logic Controllers (PLC). This decision was based due to the following reasons

- 1.They are very fast
2. Easy to change logic i.e. flexibility
- 3.Reliable due to absence of moving parts
- 4.Low power consumption
- 5.Easy maintenance due to modular assembly
- 6.Facilities in fault finding and diagnostic
7. Capable of handling of very complicated logic operations
8. Good documentation facilities
9. Easy to couple with the process computers
- 10.Analog signal handling and close loop control programming
11. Counter, timer and comparator can be programmed
12. Ease operator interface due to colourographic and advisory system introduction

Since it is a large scale implementation that we are proposing, PLCs would be the perfect choice.

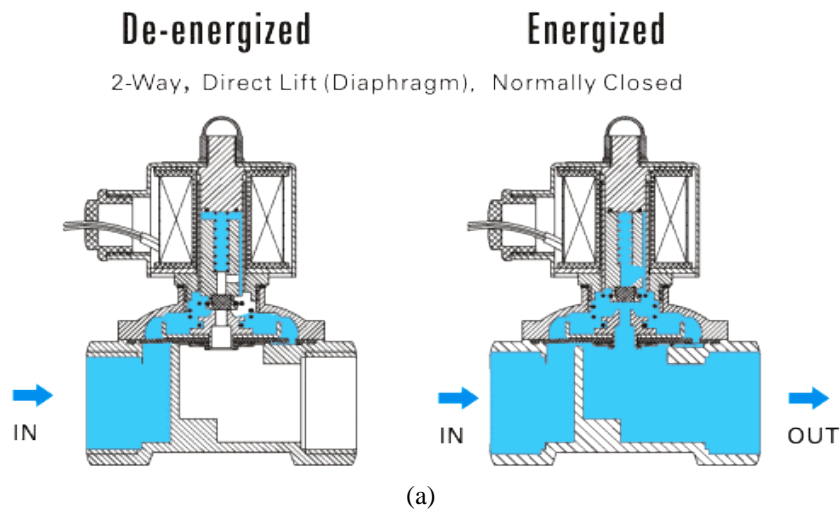
In order to create a connection between the user and the PLC, we make use of the Human Machine Interface panels(HMI). This is used to provide the user with a control forum. Using this he can control what ever process he wants either manually or automatically. Even the entire layout of the plant can be shown on the HMI screen and the status of the electrical or electronic components connected to the PLCs can be view. This provides an ease of control and monitoring for the user.

Figure 3 shows the pictures of the PLC and the HMI panels used by us



Figure 3: (a) Delta HMI DVP10SX (b)Fuji Monitouch HMI

We made use of solenoid valves to change the channels or path through which the water would flow based on the process defined. This is how we automate the process. The solenoid valve is a valve where when electrical signal is given to it will create a magnetic flux amongst its windings which will in turn open an orifice or a pathway. Figure 4 shows the working of a solenoid valve and our installation of the valves for our project.



(b)

Figure 4: (a) Solenoid valve working (b) Implementation of the valve in this project

III. WORKING

As mentioned before we are to automate four different processes related to agriculture which are as follows,

1. Drip Irrigation
2. Fertigation
3. Pesticide Sprinkling
4. Filter Clog Removal

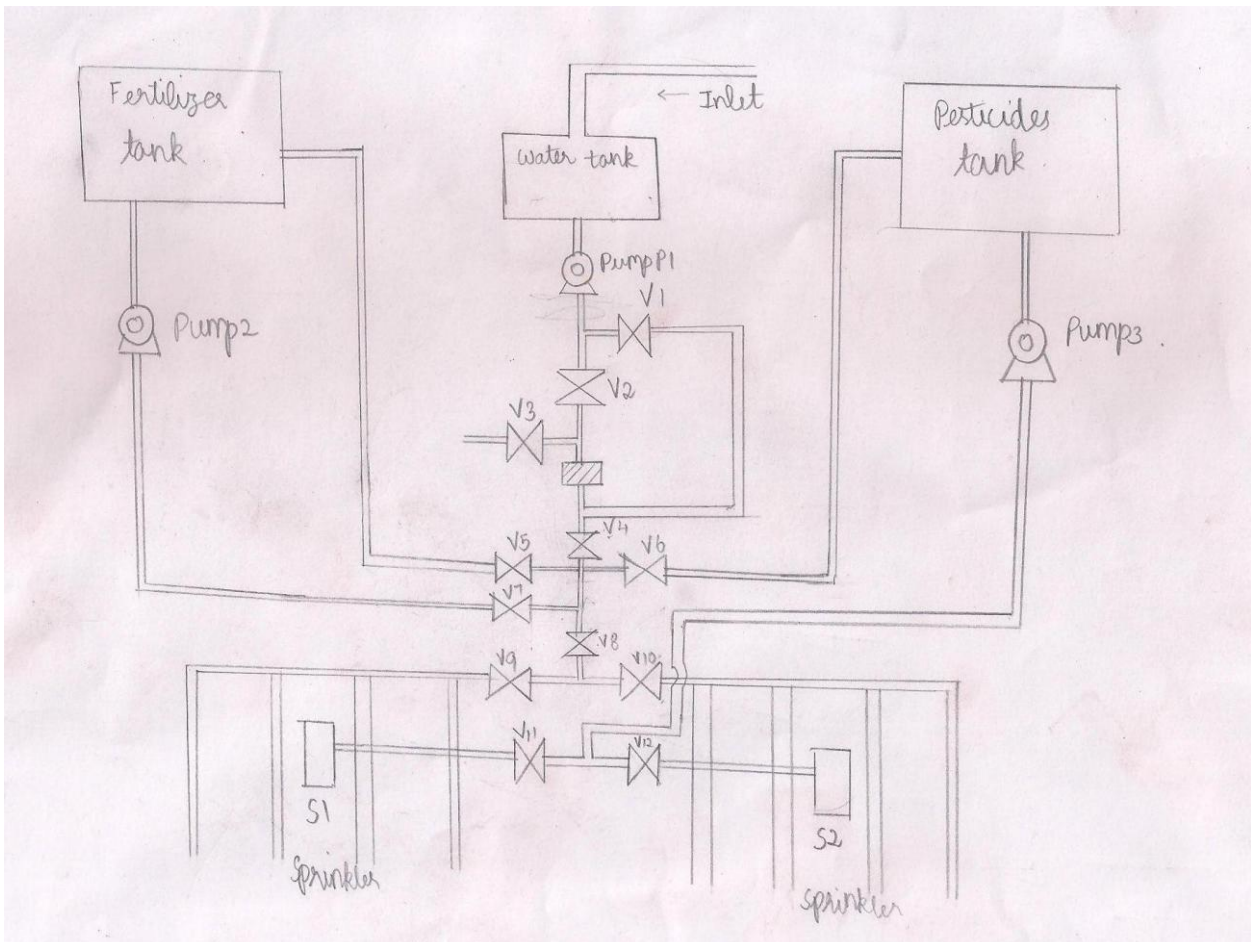


Figure 5: Layout Diagram

For automating the drip irrigation process we consider the values of the soil moisture and atmospheric humidity sensors. It would be an AND condition which we will be considering (i.e.) the values of both the sensors are to be below 60%. Only then will the process take place. If the valves v2,v4,v8 and either valve v9 or v10 are open with the main pump running, the irrigation process takes place.

As far as fertigation process is concerned it takes place only once in 20days. This can be achieved by means of a timer. Every-time the timer reaches a time limit of 20days, the fertigation process takes place. For this process the water is first filled into the fertilizer tank by actuating the main pump and the valves v2,v4 and v5. After this is done, the pump2 is turned on and the valves v7,v8 and either v9or v10 are opened.

For pesticide spraying process the farmer has to inspect the field for pests and then ON the switch if there is any. Similar to the previous process water is first filled into the pesticide tank by actuating the main pump and the valves v2,v4 and v6. After this is done, the pump3 is turned on and either v9or v10 are opened.

Based on the pressure sensed by the sensor the valves v1 and v3 are opened with the other valves in closed state. This reverse flow removes the clog present in the filter system.

IV. RESULT

With the above conditions we programmed the PLC and interfaced the HMI panel with it. The process performed with no hitch in its flow. the expected result was obtained. Below are the pictures of the different screens of the HMI .

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(a)



(b)



(c)



(d)



(e)

Figure 6: (a) Manual Valve Control Screen, (b) Automatic Irrigation Control, (c) Automatic Fertigation Process, (d) Automatic Pesticide Dispensing, (e) Valve Status screen

V. CONCLUSION

We have successfully implemented the above mentioned procedure for establishing a customized agricultural automation and had obtained the desirable results. Several more innovations are possible in this sector and will be of great help to bring about a positive change in this sector. On the whole this is a field that is to be given utmost importance as the very existence of human life depends on it.

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