

# Design and Experiment of Intelligent Control System of Crop Partial Root-zone Alternative Irrigation

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**Abstract**—The existing alternative irrigation devices are still stuck in the stage manually select the irrigated area through human operation to achieve the selected area of irrigation, time-consuming, response speed is slow. The existing irrigation devices need to use other means of experimental observations to determine the actual moisture content of the different regions of the crop root zone to determine which area needs irrigation and when it needs irrigation, has seriously affected the accuracy of the control. In this paper the intelligent control System of crop partial root-zone alternative irrigation are designed, the overall structure and principle of system are introduced, designing the hardware and software of the system, done the test. Experiment results indicated that the system has fast response, good stability, and water using efficiency increased by 9%. This system is suitable for controlling the partial root-zone alternative irrigation automatically, the corn, cotton, potatoes and other field furrow irrigation of crops and fruit trees and greenhouse vegetable crops.

**Keywords**—alternative irrigation; control system; water-saving; control signal; control module; soil moisture sensor

**Introduction**

## I. INTRODUCTION

Kang Shaozhong etc. in 1997 put forward Partial root-zone Alternative Irrigation technique based on the principle of water-saving irrigation technology and the signal theory which crops perceived source of water shortage. The technique is that person actively control the soil moisture conditions of the crops' root-zone in an area in the horizontal or vertical profile, so that the root-zone is always part of which grow in dry or relatively dry environment. The order is restrictions on the part of the root water uptake, so that the roots of the dry zone produce water stress signaling to stomata to regulate its movement, however, in a humid area roots absorb moisture from the soil to meet the crop's water requirement for life and health, at the same time, make the damage to the crops remain less than the critical limit. As always only the part of the topsoil

keep moist, it can reduce the invalid evaporation losses and the total irrigation water trees, can also reduce soil mechanical strength, to improve the permeability of the soil to promote root compensatory growth, improve the utilization of the roots for moisture, nutrients, and improve the effectiveness of mineral nutrients, in order to achieve without sacrificing crop photosynthetic products accumulate a large number of water-saving purpose.

The existing alternative irrigation devices are still stuck in the stage manually select the irrigated area through human operation to achieve the selected area of irrigation, time-consuming, response speed is slow. The existing irrigation devices need to use other means of experimental observations to determine the actual moisture content of the different regions of the crop root zone to determine which area needs irrigation and when it needs irrigation, has seriously affected the accuracy of the control, often miss the critical period of crop water requirement resulting in underproduction. In this paper a kind of partial root-zone alternating irrigation control system is designed, it can realize the mechanization and automation in the water-saving field, saving manual labour, saving water. the applicable criteria that follow.

## II. COMPONENTS OF ALTERNATING IRRIGATION CONTROL SYSTEM

### A. The function of the components

The components of intelligent control system of crop partial-root alternative irrigation are shown in Fig.1. Soil moisture sensors which used FDS Series sensors are used for real-time collection of crop root zone soil moisture, and converting it into a voltage signal, the voltage signal in the range 0 ~ 1V; Signal amplification circuit is used for magnifying voltage signal to 0 to 5V, and transferred it to the sample and hold circuit.

Supported by 863 Program of Chinese Science & Technology ministry(2011AA100505) China Agricultural University Basic research fund project.(2012yj097)

The sampling root zone is the left and right sides of the crop root zone. The sample and hold circuit realize the stability of the voltage signal. A/D conversion circuit by the ADC0809 is used to convert the voltage analog signal to 8-bit digital signal and make it transmit to the control module; The major of the control module is 51 single-chip microcomputer. Utilizing the upper limit of the crop soil moisture, the lower and the voltage signal from the signal acquisition module, according to the judgment process, the control module can control the motor drive module, and control the display shows the data. The motor drive module by L298N is used for driving the motor in irrigation systems to irrigate crops alternately. The power of the control system comes from solar energy which selected the solar panels of polysilicon , the main performance parameters: open circuit voltage of 11 V, short circuit current of 37 mA, operating voltage of 9V, operating current of 22 mA . Indirect supply selected the nickel-metal hydride battery, the output voltage of 6 V, the discharge capacity of 2100 mAh .The display can receive control signal from the control module and display the data stored in the control module. The data shown include the following: Soil moisture of the different crop root-zoon which is collected by soil moisture sensor、 the alternate threshold of moisture differences in lateral root district which is acquired in the experiment、 the upper and lower limit about the soil moisture of irrigated crop, and the relative position of current irrigation root zone, Display is Chinese liquid crystal display module.

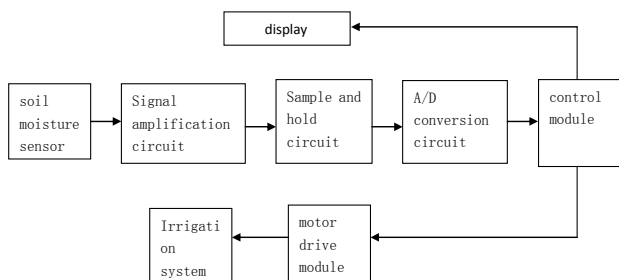


Figure 1. Components of the alternative irrigation control system

### B. Power consumption of system

The power consumption of system from five parts: soil moisture sensors, A/D conversion circuit, the control module ,motor drive modules and solar battery charging control unit, and their respective maximum power consumption indicators in Table 1.

TABLE I . POWER CONSUMPTION OF SYSTEM

	Operating voltage/V	Operating current/mA
soil moisture sensor	6.0	25
A/D conversion circuit	3.0	5
control module	5	2000
motor drive modules	4.5	2000
Charge control	6.0	8

### III. SYSTEM PRINCIPLE

The principles about the choice of the root zone are: for general field or greenhouse crops are interval furrow irrigated in the left or right sides of the root zone, for fruit trees, according to age, within the crown projection 1/3 to 1/6 district.

Figure 2 shows the flowchart of the control system. Control module control the motor of the irrigation system on the lateral root zone moisture difference alternate threshold, the upper/lower limit of soil moisture of the irrigated crops, and real-time information of soil moisture. When the soil moisture of root zone is below the limit, the control module controls the motor of the irrigation system start the root zone irrigation until the root zone soil moisture content is not less than the lower limit. Further determining the lateral root zone soil moisture difference whether it is below the alternate threshold, if so, the control module will control the motor of the irrigation system start to irrigate to the side which the soil moisture in the root zone is relatively low, until the soil moisture in the root zone gets to moisture maximum; If not, determine whether the soil moisture content of the root zone in which soil moisture content is relatively low is lower than the maximum soil moisture of the irrigated crops, if so, the control module controls the motor of the irrigation system start to make the relatively low soil moisture root zone irrigation, until the root zone's soil moisture gets to the upper limit of the soil moisture content.

The control module controls the motor of irrigation system to start, the specific steps are: opening the alternative sluice valve in irrigation system, starting motor drive modules in the control module、 opening the corresponding water outlet or hair canal of irrigation root-zoon that needs irrigate, the motor drive module drives the motor of irrigate system to carry on a work.

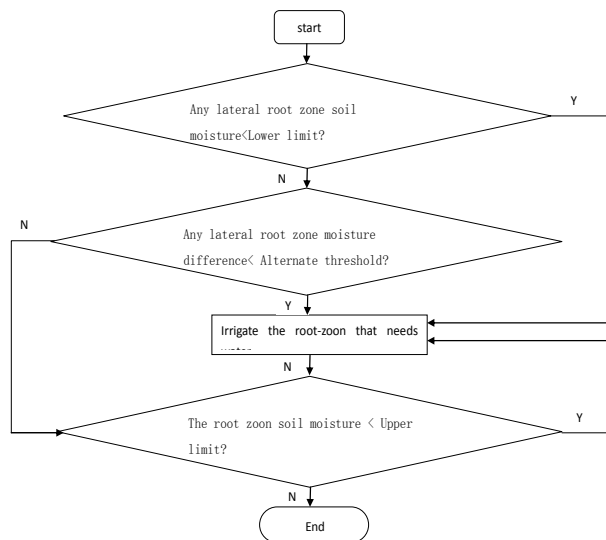


Figure 2. Flowchart of the control irrigation

#### IV. APPLICATION OF CONTROL SYSTEM IN THE FIELD

##### A. The laying of the control system

Figure 3 shows the application of intelligent control System of crop partial root-zone alternative irrigation in the field on furrow irrigation, drip irrigation and micro sprinkler irrigation. The controlling system is installed on the branch tube of furrow irrigation, drip irrigation and micro sprinkler irrigation. Figure (a) shows that the way of infusion is furrow irrigation, the object of infusion are corn、 cotton and potato etc or fruit trees and greenhouse plants. Figure (b) shows that the way of infusion is drip irrigation and micro sprinkler irrigation, the object of infusion is fruit tree.

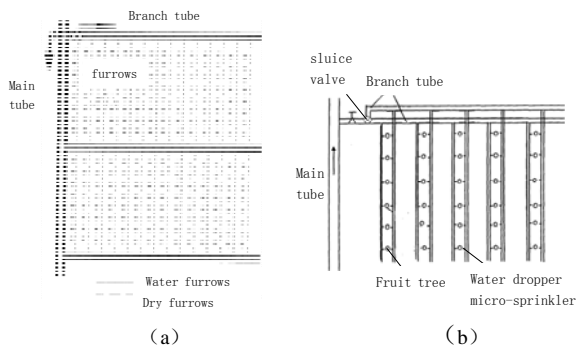


Figure3.The application of control system in the field

##### B. The laying of the sensors

Three sensors were arranged in the front、 middle and back of a row, the average of the monitoring data were taken as the soil moisture signal. In the depth, when we selected the buried location of the sensor, based on plant physiology and the root of the field crops are shorter, the soil moisture within 20cm of the ground has a direct impact on the crop growth. Therefore, in two places where are the distance 8cm, 20cm from the ground laid a single sensor respectively. The controller controlled the valve's opening according to the upper sensor data and the lower sensor data is used to determine whether the soil moisture have reached the appropriate default value to control the valve closure. The position of the sensors are shown in Fig.4.

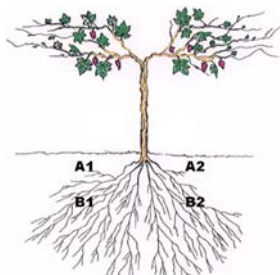


Figure4. Position of the sensors

##### C. Experiment and results

A series of tests on the irrigation system were conducted in the experimental plots of China Agricultural University. The watering objects were an age of hawthorn trees. Fig.5 shows

the change curve of soil moisture that were from the surface 8cm and 20cm from 26 April to 29 April 2012. According to the hawthorn's drought-tolerant features, the system was set the sensor at 8cm to control the valve opening when the soil moisture threshold get down to 27% ,set the sensor at 20cm to control valve closing when the soil moisture threshold get to 20% . From the change on the water content of soil can see that at the 8cm was basically stable at around 27%, the water content at 20cm was basically stable at around 20%, which indicates that meeting the haw physiological needs, while also effectively preventing water infiltration to take away the nutrients, pollution of groundwater and wasting of water resources It can achieve accurate controlling water-saving irrigation purposes.

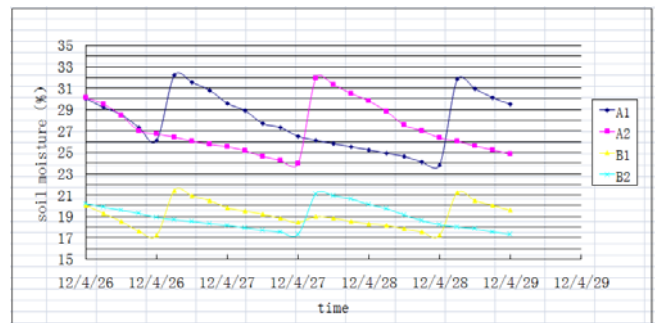


Figure5. Soil moisture detection

#### CONCLUSIONS

Test results shows that intelligent control system of crop partial root-zone alternative irrigation can realize intelligent judgment and automatic control for alternative irrigation cycle and irrigation time. It can be applied to corn, cotton, potatoes and other field furrow irrigation of crops and fruit trees and greenhouse vegetable crops, have energy- water and land saving, low-cost, simple operation and precision performance features, To facilitate large scale.

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