Solar Powered, Controlled Irrigation System at the UDC Experimental Farm

Samuel Lakeou, Ph.D. (1, 2), Esther Ososanya, Ph.D., Atoum Laith, BSEE, Carlos Quiroga, BSEE , Nunez Jessica, BSEE, Samuel Diarra , Senior, Missi Sogbohossou, BSEE Brice Koukoua, and Raju Shrestha, MSEE
Professor and Chairman, Department of Electrical and Computer Engineering
Director, Center of Excellence for Renewable Energy
(3) Professor, Department of Electrical and Computer Engineering
University of the District of Columbia, Washington, DC, USA

ABSTRACT

The work describes a solar powered, micro-controlled irrigation system implemented at the University of the District of Columbia's Experimental Farm. The goal of the project is to design a smart irrigation system powered by a sun-tracking solar power system. The system is tailored to the type of food crop being grown. It uses an automatic irrigation system which incorporates the theory of digital control and feedback. This helps reduce the problems associated with water waste in farming. It also increases food crop production. The project has a water level control system and a water distribution system. The water level in the tank is controlled by a float switch. The float switch will maintain the water tank full at all time and uses a well as a source of water. If the water supply in the well is insufficient, a service line is used as an alternative and for demonstration purpose. The water distribution system is composed of a microcontroller, various wireless moisture sensors, a solenoid valve and the irrigation pipes. A moisture sensor sends information about the soil humidity level to the microcontroller. The distribution pipe is connected to a solenoid valve. When the moisture of the soil is below desired level, the solenoid valve is switched on to initiate irrigation of the selected area. There is scheduled irrigation duration for each area based on the crop type. The system is proposed to be a model for a self-powered, standalone small scale irrigation system, ideal for semi-rural farming.

INTRODUCTION

UDC, as a land-grant university, owns a research farm: The Muirkirk Agriculture Research Farm , located in Beltsville,MD used for:

- Food production uses, including irrigation;
- Aquaponics, and
- Hydroponic systems

Main shortcoming:

- Traditional fossil fuel based agriculture, unfit to feed the future generation

PROJECT OBJECTIVE

- To provide renewable energy sources (solar) to produce power(electricity);
- To extract groundwater and store into a cistern reservoir at above ground; and
- To design a "smart" irrigation system that will be powered by solar energy

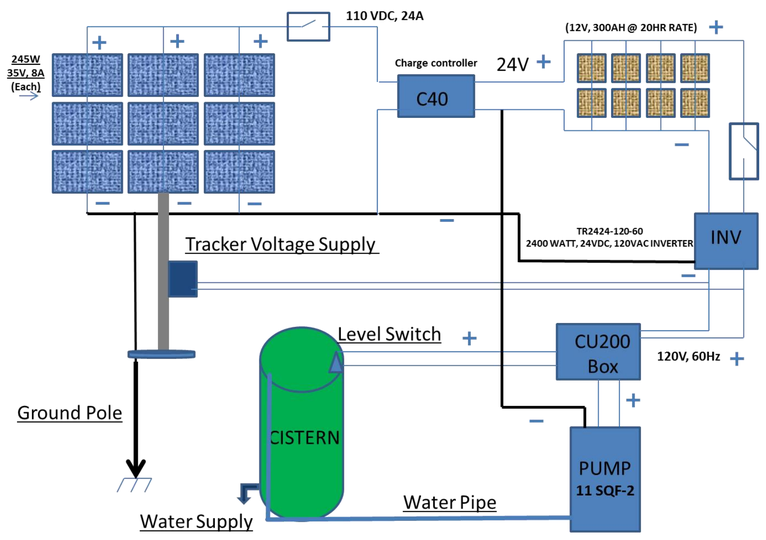
DESIGN APPROACH:

- Evaluate the power need of a water well based system
- Design a sun-tracking pole-mounted solar power system
- Install wireless moisture (T and H) sensors for crop irrigation
- Establish crop dependent T and H set points for water flow trigger
- Provide a HUB for gathering moisture data
- Provide a PID controller for data analysis and smoothing
- Provide control signal of a solenoid valve for water
- Provide internet access for displaying information on a dedicated we-site

POWER REQUIREMENT:

- Submersible pump operation: 30-300 VDC or AC , PE. (900W)
- Solar tracker PV module operation: 120W, 24VDC solar tracker motors
- Microprocessor and other miscellaneous: 1W
- Water Flow controller: 12-40V DC/AC, 120W
- Solenoid Valve: 24 VAC 50/60 Hz

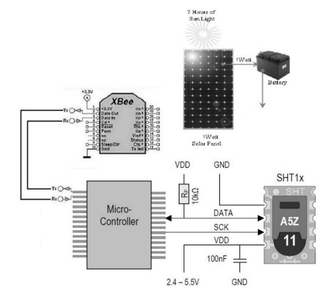
Power supply design



- Solar (double axis) tracker system: AZ-225
- Nine 6T Helios Solar Panel: 183W x 9
  At typical cell temperature: insolation 800W/m2, ambient temperature 20ºC, wind speed 1m/s.
- Eight "GEL" batteries:12V, 300AH @ 20HR RATE
- INVERTER: 2400 WATT, 24VDC, 120VAC
- Charge controller: C40
- Control box
- Submersible pump: 900W
- 5,000 Gal Cistern (reservoir)

COMPLETE INSTALLATION ON UDC's FARM

Self powered sensor node



Components:

- Arduino UNO microprocessor
- XBee Series 1 Shield
- SHT1 moisture sensor
- 6V DC Solar Panel
- Tenergy 9V 250mAh NiMH high capacity rechargeable Battery

Main function of the node:

- Collect Temperature (T), Relative Humidity (RH) and Dew Point Td)

$$T = d_1 + d_2 \cdot SO_T$$

VDD	d_1 (°C)	d_1 (°F)
5V	-40.1	-40.2
4V	-39.8	-39.6
3.5V	-39.7	-39.5
3V	-39.6	-39.3
2.5V	-39.4	-38.9

SO_T	d_2 (°C)	d_2 (°F)
14bit	0.01	0.018
12bit	0.04	0.072

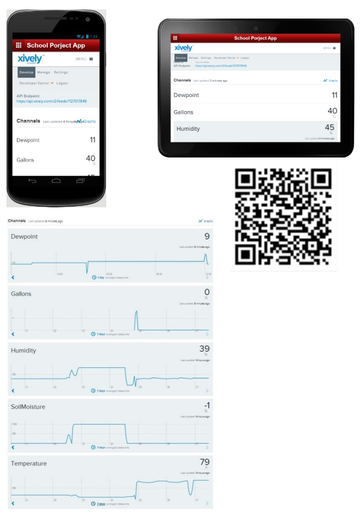
$$RH_{true} = (T_{°C} - 25) \cdot (t_1 + t_2 \cdot SO_{RH}) + RH_{linear}$$

SO_{RH}	t_1	t_2
12 bit	0.01	0.00008
8 bit	0.01	0.00128

$$T_d(RH,T) = T_n \cdot \frac{\ln\left(\frac{RH}{100\%}\right) + \frac{m \cdot T}{T_n + T}}{m - \ln\left(\frac{RH}{100\%}\right) - \frac{m \cdot T}{T_n + T}}$$

- Send data wirelessly to HUB (ZigBee protocol)

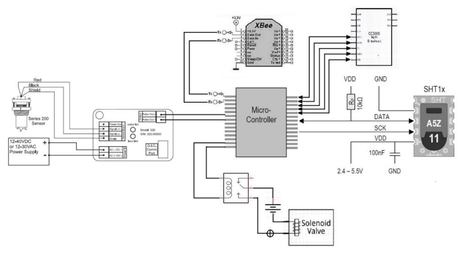
Internet of things



Main function:

Data pushed into a public website cloud, displaying all the data collected from the farm

The HUB

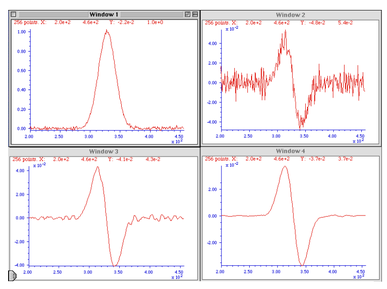


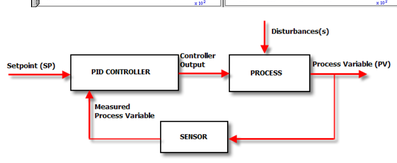
Components:

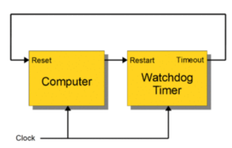
- Arduino UNO micrprocessor
- Xbee Series 1 Shield
- Solenoid Valve (PESBR)
  Pressure: 20 to 200 psi
  Flow: 0.25 to 200 gpm
- Relay for valve control
- Flow meter (series 200)/monitor
- WiFi Shield (CC3000)

Main function of the HB:

- Gather data from sensors through Xbee
- Process data with the microprocessor with Data Smoothing and PID controller scheme
- Open/close the Solenoid Valve based on threshold (Set Point) set for each crop
- Sense the water flow and record data
- Send all data to the "cloud" for internet access
- Watch dog capability







CONCLUSION

This project does not only create major solutions for worldwide problems, but also gives alternatives to businesses and farms to grow and become more productive. At the farm owned by The University of the District of Columbia, this system will give an innovated solution to the problems of water wasting and crop productivity. Therefore, the system will help thefarm to expand itself, so more crops can be grown in different fields. We are not only interested in implementing the system at the farm of The University of the District of Columbia, but we are also interested in Bringing our system to continents such as: Africa and Asia and create major solutions.

ACKNOWLDGEMENTS

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