Solar Powered Automated Irrigation System

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Abstract: *The variation of spatial and temporal distribution of available water for irrigation makes significant demand on water conservation techniques. Hence solar powered Automated Irrigation System provides a sustainable solution to enhance water use efficiency in the agricultural fields using renewable energy. This system allows farmers to apply the right amount of water at the right time. This system can automatically irrigate the fields according to the pre-defined conditions. It allocates water according to the crop water requirement and availability of solar radiation. The results revealed that, system would be a best option for medium size agriculture field. And this automated system water wastage of the tested field could be reduced by 50% of normal irrigation wastage. Besides, human attention was reduced on irrigation significantly. This intelligent system can be improved by adding temperature and total dissolve solid sensors. As well as system can be program using 8051 40 pin microcontroller and it will reduce the power consumption. Apart from that, the system can be developed to control remotely by using internet and GSM technology and field condition can access by the farmer from anywhere in the world*

Keywords: *Solar powered, Automated irrigation system, Water use efficiency*

1. INTRODUCTION

Irrigation water has become a scare resource due to the special and temporal availability of irrigable water. Mainly, bimodal rainfall pattern of Sri Lanka is considered as main source of rain fed agriculture. Other than that, irrigated water management practices could be found in major irrigation schemes. Most of the irrigation schemes, allocate water in bulk form and presently the irrigation efficiency in farmer's field is about 30 to 40 percent. The water loss, not available to crops is about 60 to 70 percent (Lewis, n.d.). Thus, it is necessary to enhance Water Use Efficiency (WUE) in irrigated lands. Food and Agriculture Organization (FAO) has suggested many promising strategies for raising WUE. The strategic water management practices are soil-water conservation measures through crop residue incorporation, adequate land preparation for crop establishment, rainwater harvesting, and conservation tillage to increase water infiltration, reduce runoff and improve soil moisture storage. In addition, novel irrigation technologies such as supplementary irrigation (some irrigation inputs to supplement inadequate rainfall), deficit irrigation (eliminating irrigation at times that have little impact on yield) and drip irrigation (targeting irrigation water to plant in root zones (FAO, 2006).
Moreover, the variation of spatial and temporal distribution of available water for irrigation makes significant demand on water conservation techniques. Further, continuous extraction of water from ground water table, creates numerous current and future consequences for mankind. Finally, the water crisis could be lead to conflicts among different communities by creating numerous socio-economic issues. Hence, it is crucial to investigate sustainable solutions for the development of the nation.

Even though, the micro irrigation systems are used in different agricultural fields, most of them are regulated manually. It requires regular intervals to operate using man power and it reduces the efficiency of the large scale irrigation lands. In addition, this regular interval operation system based on man power, leads to excess water allocation than the crop water requirement and insufficient water allocation when plants requires more water based on diurnal variation and seasonal changes. Water deficiency can be detrimental to plants before visible wilting occurs. Retardation of the crop growth rate, late flowering, and reduction of the yield are some of the significant effects which can be caused due to water deficiency. Moreover, excess water in the root zone cause ill health of the root zone and vegetation, additional cost for farmer, wasting of water and time wastage. Salinity of the soil can be increase due to the continuous

rising of water table in long run with the excess application of water.
Hence solar powered Automated Irrigation System (AIS) provides a sustainable solution to enhance water use efficiency in the agricultural fields using renewable energy. It provides water for plants according to the crop water requirement and this system operates according to the soil moisture condition of the root zone of the plant. The system has designed to operate using solar energy; hence it could be used for the areas where the accessibility of National Electricity grid is not popular. Further, it does not affected by the energy crisis which can be altered the livelihood of the public. The proposed system helps to control irrigable water over the agricultural fields. Thus it reduces excessive pressure on farmers to pay additional water tariff on water. In addition pump water irrigation also save additional cost for water pumping, reduces the conveyance and distribution losses in the field level. Moreover, energy consumption on water pumps could be reduced by efficient water allocation based on the crop water requirement.
Further, automated irrigation system allows farmers to apply the right amount of water at the right time. This solar powered system does not require man power for operation. This intelligent system can detect the soil moisture availability and perform automatically based on pre-defined logical conditions. This system reduces run off from over watering saturated soils, avoid irrigating at the wrong time of the day, which will improve crop performance by ensuring adequate water and nutrient balancing. Further, it prevents Salinity of agricultural lands which cause for poor productivity and land degradation etc. In addition, this system helps in time saving, removal of human error in adjusting available soil moisture level and to maximize their net profit.

The best time of day to irrigate is the subject of some debate. One group suggests that early morning is the best time, while another group claims that afternoon is the best. Very few people consider night irrigation to be a viable alternative due to concerns of increased disease pressure. In all practicality, disease is not increased except when lawns are routinely over-irrigated (The Clemson University Cooperative Extension Service).
According to the Stuart et al. (Stuart *et al.,* 2004), they have concluded that, irrigation timing had a significant effect on plant growth, container temperature and water use efficiency.
Considering above facts on irrigation time there is a necessity to operate the irrigation system in night time as well and reduce the evopotranspiration.

The main objective of this study is to develop a solar powered automated irrigation system for efficient water allocation for fields based on crop water requirement using renewable energy.

2. METHODOLOGY

Experimental setups were arranged and experimented using relevant hardware components and software components. Sensor parts of the circuit was developed using op-amp IC LM324. Soil probes used to detect soil moisture levels. AT89C2051 microcontroller was used for decision making process. Pre-defined operational conditions were used to operate the system without any failure. Algorithms were developed logically and it was used for software development of the system. Assembly language was used to write the program in to the microcontroller.

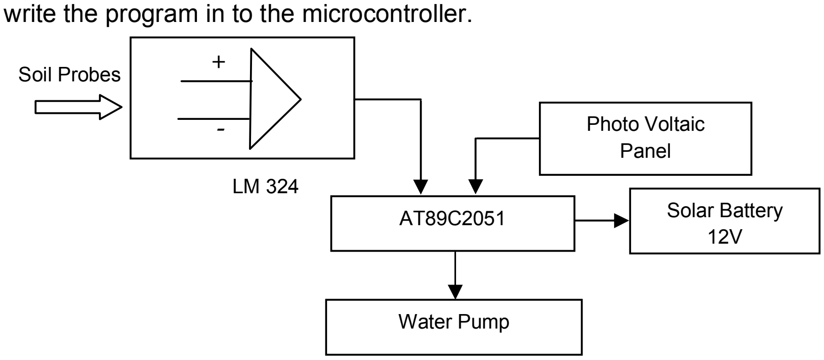

Figure 1: Diagram of Automated Irrigation System

2.1. Hardware Components Used for the System Development

AT89C2051 microcontroller, LM 324, PV module, solar battery, simple electronic circuits were used as the main hardware components for the development of solar powered AIS.

Table 1 Microcontroller Based Solar Charger Circuit

Device	**Types of the Device**
Semiconductors	AT89C2051, ADC0831, NTE 3041, 7805(5V), BC547(npn), BS170, IRF540, 6A4, 1N4007, 7.5V zener diode
Resistors	8.2kΩ, 1.2kΩ, 10kΩ, 20kΩ, 330Ω
Capacitors	100µF(63V), 100µF(16V), 0.1µF, 10µF(16V), 33pF, 0.01µF
Miscellaneous	On/off switch, Push-to-on switch12V, 1C/O relay, 12MHz crystal, 16x2b line display, Photo Voltaic(PV) module, 10A fuse, 10 pin connector, solar battery

Table 2 Automated Irrigation System

Device	**Types of the Device**
Semiconductors	AT89C2051, LM 324, BC547, 1N4007
Resistors	56kΩ, 100kΩ VR, 330Ω
Capacitors	1µF(16V), 33pF
Miscellaneous	12V Relay, 12MHz crystal

When consider the main hardware components, AT89C2051 microcontroller was used to regulate the operation of solar battery and the water pump. Meteorological parameters and electrical parameters were taken as inputs for the microcontroller. Solar intensity and soil moisture levels were considered as the meteorological inputs which were detected by different sensors. Photo Voltaic (PV) panel voltage and solar battery voltage was considered as the electrical inputs which were used to program the microcontroller.

The LM324 contains four independent high gain operational amplifiers with internal frequency compensation (LM324 data sheet, 2007).

10w, 16.8V PV module was used for the experiment and 12V, 9AMH lead acid battery was used as the solar battery.

2.2. Software

The source program for the microcontroller was written in assembly language and assembled using Keil software .which is freely available on the internet for download.

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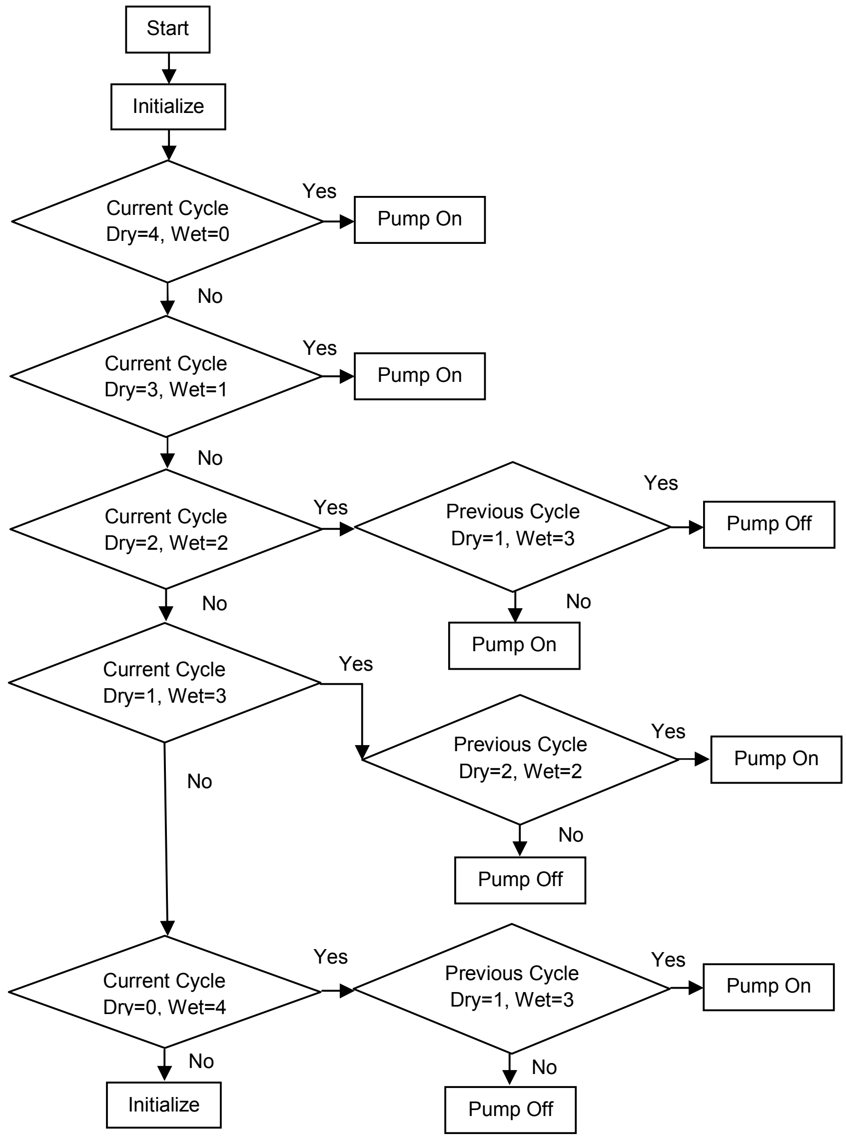
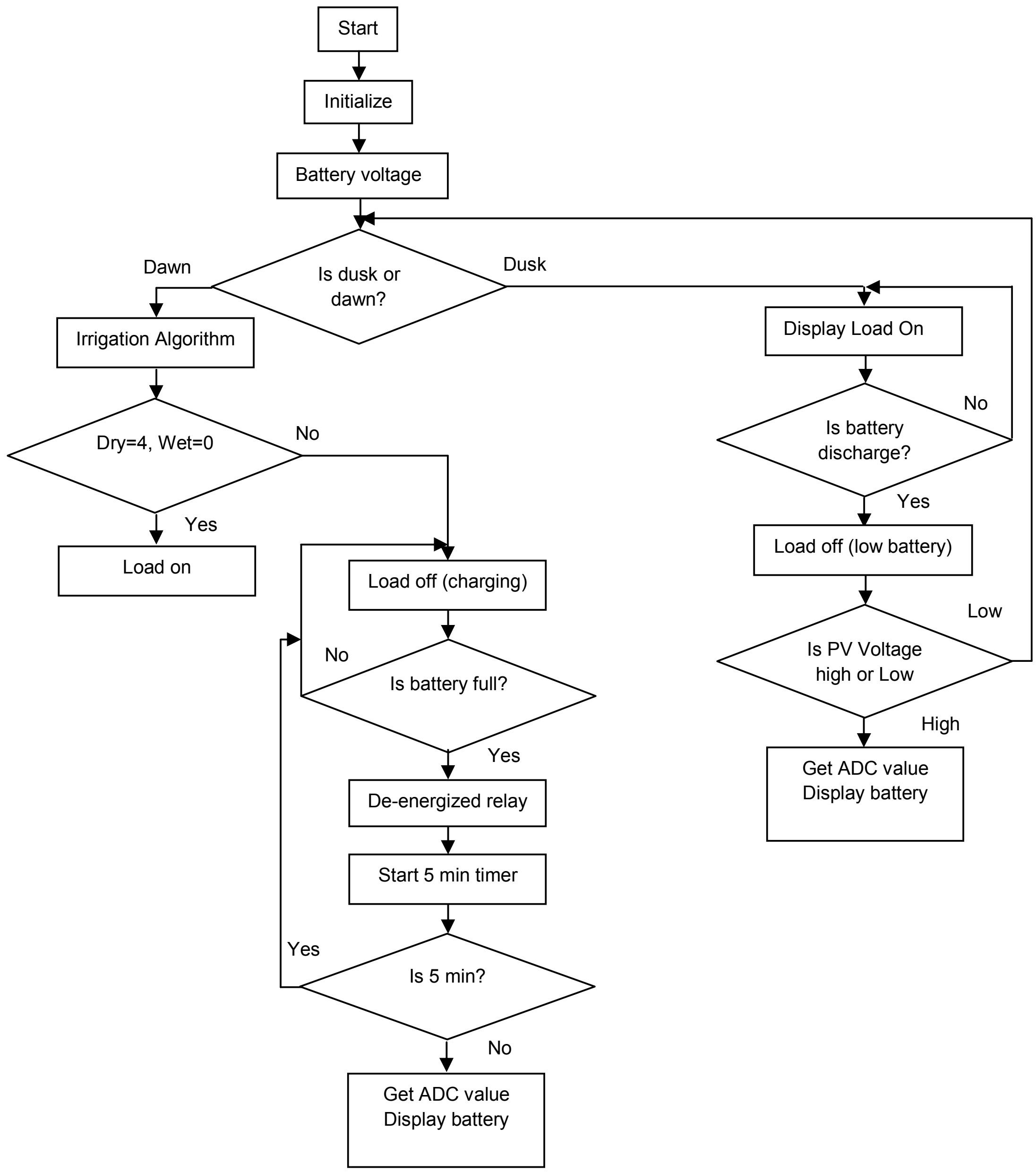
2.2.1. Control Algorithm of Automated Irrigation System



2.2.2. Control Algorithm of System Load



System load algorithm

Algorithm starts, initialize and it takes battery voltage as the initial input. At the first decision making point, system evaluates whether it is dusk or dawn. If it is dawn, operation jumps in to the irrigation algorithm. In the irrigation algorithm if it comes to emergency condition as Dry = 4 and Wet = 0, it is a critical stage for the crop and it is essential to irrigate water as soon as possible before crop comes to its permanent wilting point. In this situation system identifies its critically needs to “load on” which helps for pump operation. Otherwise, if there is no critical condition as Dry = 4, Wet = 0, system will off the load.

In a normal situation, if it is a dawn, load will off and solar battery charging will be started. In this cycle, in a particular point, it takes a decision whether battery is full or not, If battery is full, relay will be de-energized and at the same time 5min timer will be started. When timer comes to 5 min point, charging will be started again and load will be off. If timer value does not 5 min, it gets ADC value and displays battery capacity.

When it is dusk, LCD displays load on and continuously check whether battery is discharging or not. If it is yes load will make off and displays low battery. In the next decision making point it checks whether the PV cell voltage is low or not according to pre-defined voltage level in the system. If it is below the pre-defined voltage level, control jumps to check the dusk or dawn condition. If it is high, it continuously updates the voltage of the battery on LCD panel.

Irrigation algorithm
The logics of the algorithm help to identify whether water is filling to the field or whether water is evaporating from the field. Further, logics and decision making conditions help to maintain at least 25% soil moisture condition of the soil and it always maintain >25% of moisture in the field. In the algorithm, when starts a new clock cycle, it initialize and at the decision making point it evaluates whether current cycle Dry = 4, Wet = 0 and it indicates as the field in the critical stage and intelligent system give a signals to operate the pump. When it comes to a condition like “current cycle Dry = 3, Wet = 1, the field in dry condition and needs to operate water pump. In another cycle, if it comes to a condition like “current cycle Dry = 2, Wet = 2, it needs further information to make a decision. Thus, it evaluates the stored data of the previous cycle. If previous cycle is Dry = 1, Wet = 3, it is an indication of the irrigated water has being evaporating. Then pump will not be operating since it has 75% moisture level in field.

3. RESULTS AND DISCUSSION

The system was tested in the field conditions and results revealed that, system would be a best option for medium size agriculture field. Operational amplifier reference voltage could be changed according to the crop type and moisture availability in the field by using potentiometer. Excess power was stored in the solar battery and it was used when day light was low. Excess charging was prohibited by using pulse width modulation technique and it helped to reduce the temperature of the solar battery and increase the life time of the battery. When all probes were dry, water pump was switched on until all the probes were getting wet. As well as when all probes were wet, it allocated to dry till two probes and utilize the water and power sustainable manner. If further reduction of the moisture of the soil occurred, it leaded to switch on the pump till all probes getting wet. Because of this automated system water wastage of the tested field could be reduced by 50% of normal irrigation wastage and reduce evopotranpiration by induced dark time operation. Besides human attention was reduced on irrigation due to automation.

4. CONCLUSION AND RECOMMENDATIONS

This intelligent system can be improved by adding temperature and total dissolve solid sensors. As well as system can be developed by using 40 pin 8051 microcontroller and it will reduce the total power consumption and initial cost. Apart from that, the system can be developed to control remotely by using internet and GSM technology and field condition can be accessed by the farmer from anywhere in the world. Further studies should be undertaken to identify each crop water requirement and application of Solar Powered Automated Irrigation System according to the moisture retention capacity of the Field and environmental conditions. Since this is initial experimental stage, the performance evaluation criteria of the system should be thoroughly investigated.
When consider the cost of the solar powered AIS and operational cost, the initial establishment and fabrication costs are considerable. But it is more cost effective in long run. The cost of embedded system was 5000 rupees with imported duty charges of some components.

5. ACKNOWLEDGEMENTS

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