Journal
Since 1954

The Andhra Agric. J 61(2):413-420, 2014

Laboratory Model of Automation in Irrigation

D Sai Gangadhara Rao , Ch Murali krishna, A Rama Rao and Surya Kiran

College of Agricultural Engineering, Bapatla-522 101 A.P.

ABSTRACT

Sustainability of the agricultural production is the ability of the production system to enhance productivity towards the potential and maintain it without degrading the resource bases of land and water against various odds. As there more drudgery involved in agricultural pump set as well as losses like excessive water pumping, more consumption of power etc. Present day research focuses on automation of various irrigation systems. Simple electronic circuit principles were applied in irrigation, an attempt was made to develop low cost auto irrigation based on soil moisture. The movable bed paddy field of dimensions 0.9 m X 0.9 m X 0.6 m tray is used under lab scale. The tray is filled with clay soil and at bottom of the tray a drain pipe (horizontal slotted PVC pipe 32 mm wrapped with nylon mesh) is used for removing of the water to well. Commercially available aqamon make single phase auto cut off and auto cut on circuit board fixed in a box along with moisture sensors and design of low cost automation of irrigation circuit. The volume of water removed for 15 minutes interval and also total volume of water drained was calculated.

Key words : Automation of irrigation, Electrical circuits, Lab model , Observation well.

Water is a scarce and precious national resource to be planned, developed, conserved and managed on an integrated and environmentally sound basis, keeping in view the socio-economic aspects and needs of the nation and states. Optimum development and efficient utilization of water resources, assumes great significance. The average annual precipitation including snowfall is estimated to be of the order of 4,000 billion cubic meters (BCM) **(**Anonymous, 2009**).** The average annual rainfall as per the estimate of Central Water Commission (2000) is 1869 BCM which is about 4% of global supply. Out of this 1122 BCM (690 BCM from surface water and 432 BCM from ground water) can be utilized for meeting diverse demand. The present utilization has been estimated to be order of 605 BCM out of which about 83% is for irrigation purpose. The projected demand of water for various purposes by 2025 A.D is estimated at about 1050 BCM comprising 700 BCM of surface water and 350 BCM of ground water. Although, the average water availability in the country remains more or less fixed according to the natural hydrologic cycle, the per capita water availability is reducing progressively owing to increasing population. The per capita water availability is reducing with time, 5300 m^3 during year 1955 to 2200 m^3 as of now. It is projected that during 2025 this availability will be 1500m^3, which is at stress level and during year 2050 it will be scarce with availability of less than 1000 m^3.

It is proposed to develop automation in irrigation at low cost with the following objectives

1. To study and develop the low cost device (Aqamon) and methods like soil moisture depletion method used for automation of research advancement.
2. Development of a simple device functioning underneath the soil, which can assist electronic circuit board to either switch off or switch on the motor as per the required moisture/water levels.
3. To simulate the field conditions in hydraulic laboratory and to test the developed sensor circuit board for irrigation situations.

MATERIAL AND METHODS

Scheduling of Irrigation

Real time scheduling forms the basis for automation. The automation is possible with electronic circuits. Indirect way of calibrating the scheduling parameters and connecting the circuit to the starter motor forms the concept of the automation.

The automation units range from low cost to high cost equipment like solenoid valves in drip system (Anonymous, 2009) with Central Input Data Fed Systems. The general bases for automation followed by various methods are listed below:

1. Timer based automation
2. Soil moisture depletion based automation
3. Leaf conductance or resistance based automation (with the help of infrared thermometry- pyrometers)
4. Submergence water levels (like in paddy fields)
5. Water Quantity based automation (like solenoid valves etc.,)

Among five methods Soil moisture depletion based automation method was used for present research purpose.

The method of selection of automation depends on the purpose of crop production, extent of the farm, availability of water and electricity etc. The basic concepts of scheduling of irrigation followed in IRRI (International Rice Research Institute, Philippines) are shown in Plate 1.

Experimental Set up

This experiment was conducted at hydraulic laboratory in College of Agricultural Engineering, Bapatla in the period of 2011**.** A mild steel tank already available in hydraulic laboratory was used for the experiment. Above certain height, at bottom a horizontal slotted PVC pipe (32 mm) wrapped with nylon mesh envelope material (Plate 2) was fixed horizontally. This would the drain the percolated water to a tank which is connected to this pipe just outside to this MS tank. Similarly, to know the status of the water movement downwards within the soil column, a higher sized slotted PVC pipe (75 mm) wrapped with nylon mesh envelope material (Plate 3) was vertically placed in center of the soil bed. As the water level rises or depletes in the soil paddy field, the water level in this pipe will also move simultaneously because of phreatic surface which is under atmospheric pressure. The experimental set up with horizontal and vertical slotted PVC pipes wrapped with nylon mesh envelope materials for smooth water flow without clogging.

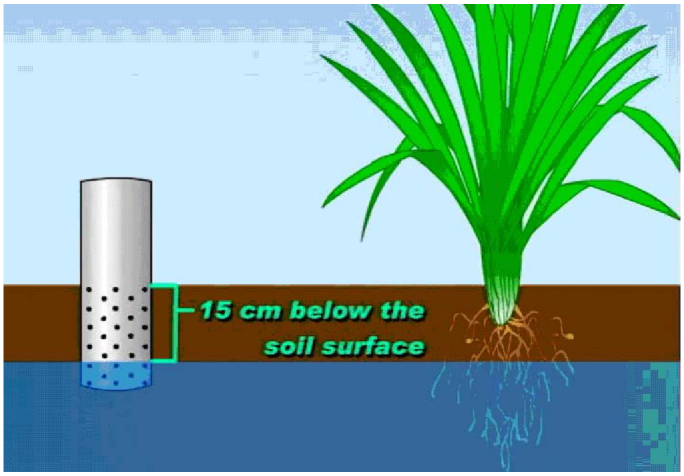
Aqamon single phase auto cutoff and auto cut on circuit board

Aqamon single phase auto cutoff and auto cut on circuit board fixed in a box along with sensors which was designed for keeping in the water tanks of domestic houses and apartments for single phase motor pump sets was used for auto irrigation. The simple circuit used in the box is presented in Fig.1. A copper wire of 18 gauge with total length of 5 m has been purchased locally, cut into three equal pieces and connected to the circuit board and sensors to facilitate the variable depths of water levels in the Perforated pipe (PVC). This circuit automatically controls the water pump motor. The motor gets automatically switched on when water level in the observation pipe falls below the irrigation starting point due to soil suction and gets switched off when the water level in the observation pipe reaches to field capacity point due to irrigation. The irrigation starting point and field capacity points are pre fixed according to the type of the soil.

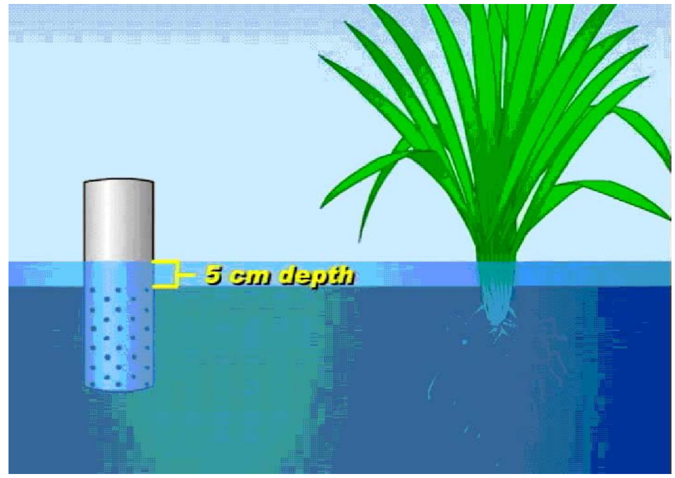
The circuit works by using NAND gate IC (CD4011), the circuit is simple, compact and economical (Aravind, 2004). It works of a 12 volts DC power supply it is given through a step down transformer and consumes a very little power.

In the above circuit diagram, “A” is the irrigation starting point and “B” is the field capacity point. The 12 volts power supply is given common electrode “C”, which is limit for minimum water in the Perforated pipe (PVC). The irrigation starting point electrode “A” is connected to base of transistor T1 (B547), the collector of which is connected to 12 volts power supply and the emitter is connected to relay RL1. Relay RL1 is connected to pin 13 of NAND get N3. The field capacity electrode “B” is connected to the base of transistor T2 (BC547), the collector of which is connected to the 12 volts power supply and emitter is connected to pin 1 and pin 2 of NAND gate N1 and ground via resistor R3. The out put pin 4 of NAND gate N2 is connected to pin 12 of NAND gate N3. The out put of N3 is connected to input pin 6 of N2 and

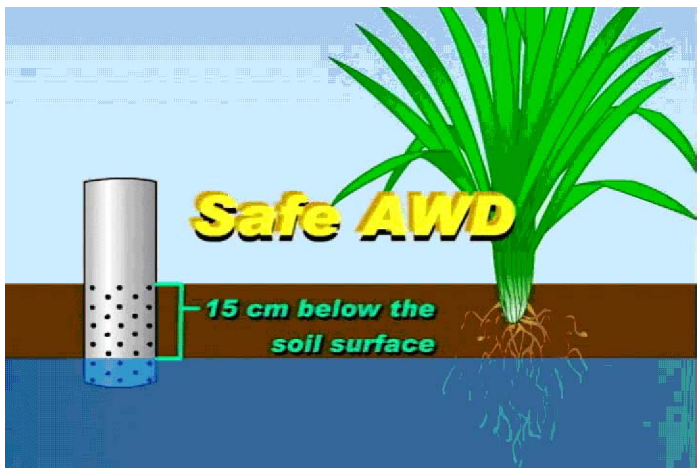
Plate 1. Safe alternative wetting and drying in paddy fields (IRRI).



(a)



(b)



(c)

Plate 2. Nylon mesh wrapped perforated pipe for drainage

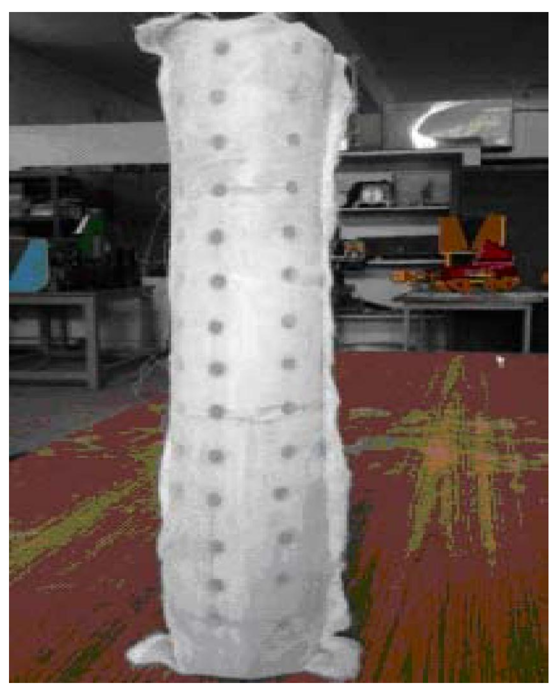


Plate 3. Nylon mesh wrapped pipe for soil particle entry into the pite

the base transistor T3 via resistor R4. Relay RL2 connected to the emitter of transistor T3 is used to drive the motor.

If the water level in the observation pipe reaches below the irrigation starting point "A", transistors T1 and T2 do not conduct and the out put of N3 goes high. This high out put energizes relay RL2 to drive the motor.

When the water level the irrigation starting point "A" but below the field capacity "B", water inside the observation pipe provides base voltage to drive transistor T1 and relay RL1 energizes to make pin 13 of gate N3 high. However, water inside the observation pipe does not provide base voltage to transistor T2, so it dose not conduct and logic built around NAND gates N1 andN2 outputs low to pin 12 of gate N3. The net effect is that the out put of N3 remains high and the motor continues working.

When the water level in the observation pipe reaches the field capacity point "B", water inside the tank still provides base voltage to transistor T1 and relay RL1 energizes to make pin 13 of gate N3 high. At the same time, water inside the observation pipe also provide base voltage to drive transistor T2 and the logic built around NAND gates N1 and N2 outputs high to pin 12 of gate N3. The net effect is that the output at pin 11 of N3 goes low and the motor stops working.

When water level falls below field capacity point "B" but above irrigation starting point "A", water inside observation pipe still provides base voltage to transistor T1 and relay RL1remain energized to make pine 13 of gate N3 high. However, transistor T2 doesn't conduct and the logic built around NAND gates N1 and N2 outputs high in pin 12 of N3, as a result the output of N3 remains low and motor remains stopped.

When water level falls below the irrigation starting point "A" both transistor T1 andT2 do not conduct electricity and NAND gate N3 gives a high output to dive relay RL2 and the motor restarts pumping water. The various components as shown in Plate 4 & 5.

Fig 1. Circuit diagram of auto start and cutoff device for irrigation

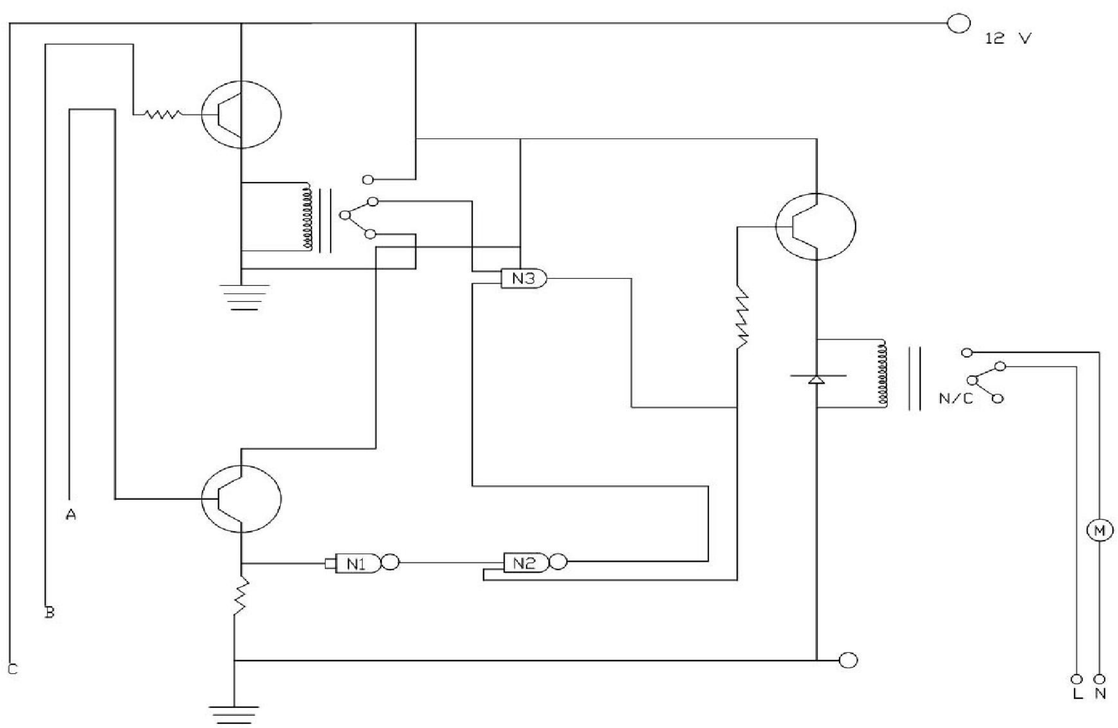
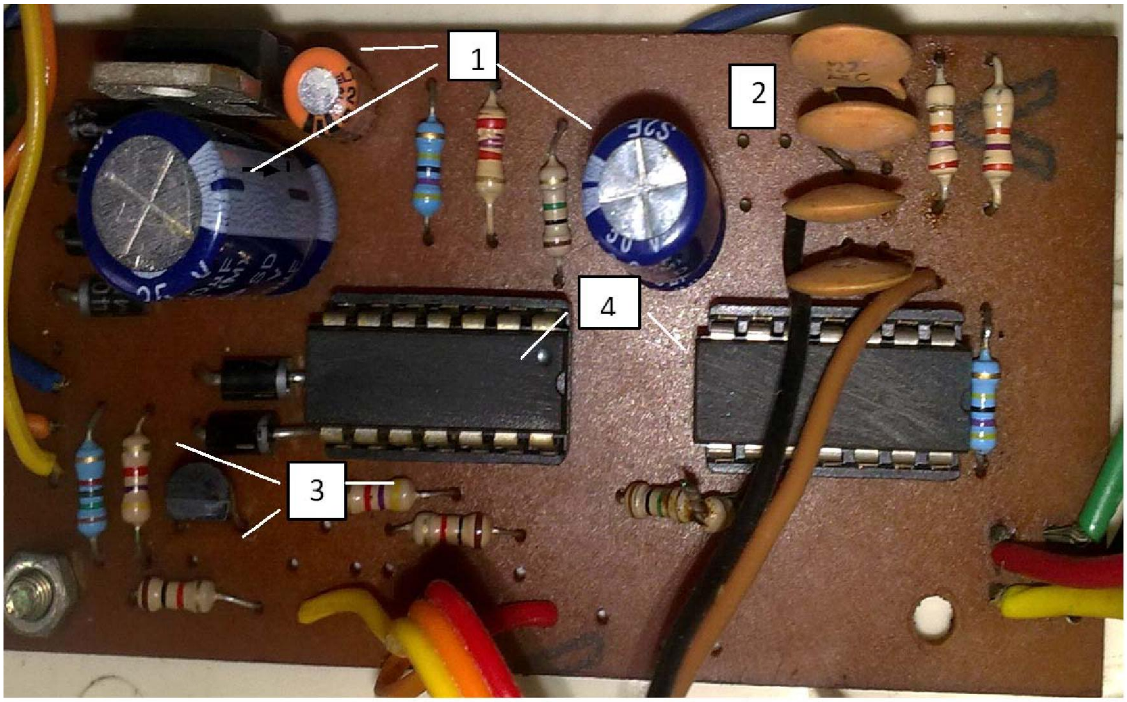
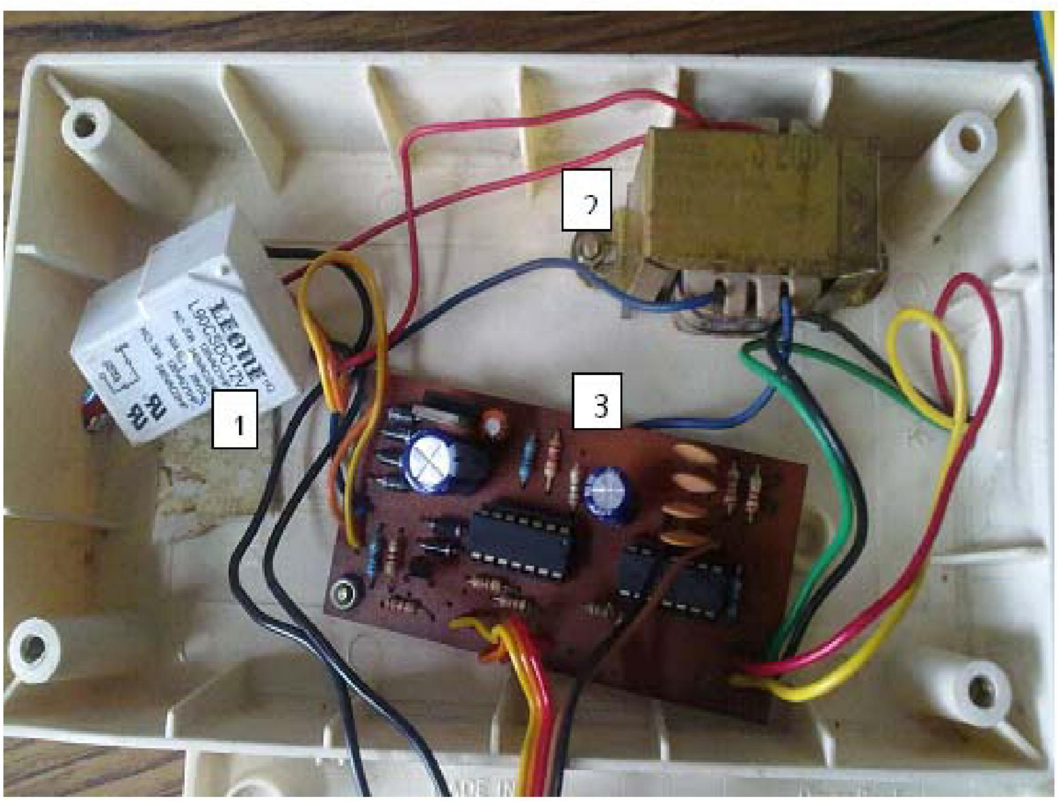


Plate 4. Relay board of single phase of 0.5 hp motor for auto irrigation



1. Capacitors 2. Diodes 3. Resisters 4. Integrated circuits (I.C)

Plate 5. Circuit of single phase of 0.5 hp motor for auto irrigation



1. Relay 2. Transformers 3. Circuit board

Table 1. Physical properties of soil sample.

S. No	Name of the parameter	Quantity
1	P^H (1:2.5 soil-Water)	7.45
2	EC (1:2.5 soil-water) dS m^{-1}	0.5
3	Bulk Density (Mg m^{-1})	1.22
4	Particle Density (Mg m^{-1})	2.60
5	Porosity (%)	53
6	Texture	Clay

Table 2. Average discharges through irrigation pump used for the study.

Trial	Volume of water collected (L)	Time required (s)	Discharge (Ls^{-1})	Average Discharge (Ls^{-1})
1	10	12.37	0.8084	0.8040
2	10	12.47	0.8019	
3	10	12.47	0.8019	

Average Discharge of the irrigation Pump (Q) =0.8040Ls^{-1}
Time taking irrigation motor to fill the mobile paddy field (Ät) = 88 sec
Total volume of water applied for Irrigation = Q X Ät = 0.8040 x 88
= 70.752 L.

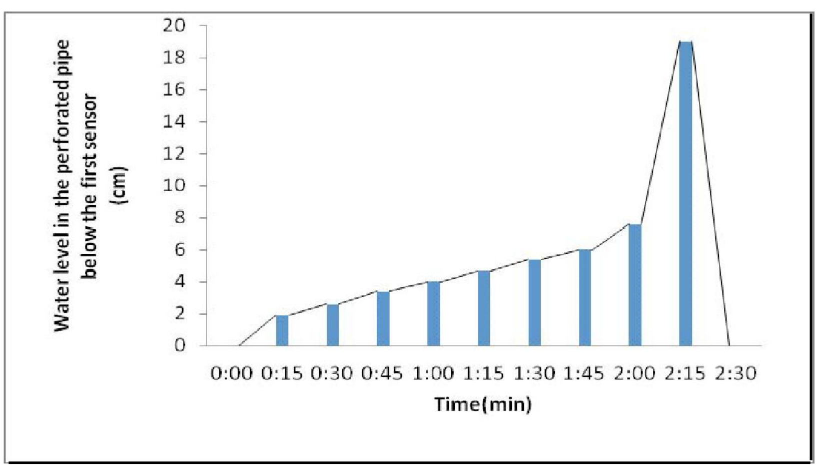


Fig 2. Water Level in the vertical slotted (observation) pipe.

Total water removed through drainage was 43 L,
Then Total quantity of water retained by the soil column of paddy filed = 70.75 – 43
= 27. 75 L.

Physical properties of soil sample

The physical properties of soil samples are used in the experimental movable paddy bed field were shown in table 1.

Volumetric Method of Water Measurement

A simple method of measuring water in small irrigation streams is to collect the discharges in a collection tank of known volume for measured period of time. The time required to fill the collection tank is reckoned with stop watch. The rate flow is determined by following formula

$$Discharge\ (Ls^{-1}) = \frac{Volume\ of\ water\ collected}{Time\ taken}$$

The same procedure is repeated three times. The average of the three discharges is taken as the average discharge of the irrigation pump.

RESULTS AND DISCUSSION

The results obtained during the experimental study was shown in table 2.

Measurement of volume of percolated water outflow

With the help of volumetric measurement, by arranging a 40 liter bucket, the percolated water was measured at the outlet of the perforated and envelope wrapped PVC pipe. The volume of water removed for 15 minutes interval is calculated and also total volume of water removed per one irrigation is also calculated and shown in table 3 and fig. 2. It helps in water balance studies for further research.

Conclusions

The water table height existing in the field has not been taken into account because of involvement of more cost. Thus, A low cost device with observation well was installed in the laboratory movable paddy bed field and tested for automatic motor switch on off for maintaining proper water leveling the bed.

It was observed that the water level in the observation well decreases with increase in time.

In many drainage systems, farmers/ operators found it very difficult to intermittently start and stop the diesel/electrical motor pump sets for the proper functioning of irrigation systems. This type of low cost device would definitely reduce the drudgery of the operators.

Total quantity of water retained by the soil column of paddy filed was 27. 75 L. Design the low cost automation of irrigation circuit with the cost of Rs.497/-.

Table 3. Measurement of water level in the observation vertical slotted pipe.

Time (min)	Water level in the perforated pipe (cm)	Water level in the perforated pipe below the first sensor (5 cm above the ground) (cm)
00:00	5	0
00:15	6.9	1.9
00:30	7.6	2.6
00:45	8.4	3.4
01:00	9	4
01:15	9.7	4.7
01:30	10.4	5.4
01:45	11	6
02:00	12.6	7.6
02:15	24	19
02:30	5	Irrigation started

Table 4. Details of different parts used in the on-off switch circuit for irrigation and their prices.

S.no.	Name of part	Specification	No. of units	Price per unit (Rs)	Total price (Rs)
1	Transformer	0-12 V	1	35	35
2	Diode	4007	4	2	8
3	Capacitor	1000 µfd	1	15	15
4	Capacitor	100 µfd	1	5	5
5	Capacitor	22 µfd	1	3	3
6	I.C(integrated circuit)	CD4011	2	50	100
7	Regulator	12V—L7812	1	15	15
8	Capacitors	0.22pfd	4	2	8
9	Resistors		13	1	13
10	Transistor	547	1	5	5
11	Electromagnetic relay	12V	1	70	70
12	On-off switch	6Am	1	10	10
13	Pressing switch	5Am	1	10	10
14	Led indicator		2	2	4
15	I.c base		2	10	20
16	Flexible wire		1 packet	10	10
17	Connectors or sockets	Plastic	2	5	10
18	Soldering lead	west-X	1 bundle	5	5
19	Paste		1 bottle	5	5
20	Solder iron	35W(tone)	1	35	35
21	Covering box	Plastic	1	50	50
22	Electrodes	Insulated cu wire	1m	5	5
23	Servicing charges	——	——	——-	50
		Total			

LITERATURE CITED

Anonymous 2009 Training Manual of Winter School on Real Time Irrigation Management using Decision Support System and Electronic Control for Precision Agriculture in Vertisols in India, *Automation of Micro Irrigation,* Pp 261-264.

Anonymous 2006 Irrigation scheduling with tensiometers, *Fact sheet irrigation scheduling techniques.* British Columbia ministry of agriculture and lands *(577):100-2.*

Aravind R 2004 *Motor control circuit using electromagnetic relay. (www.hobies.com)*

Michael A M 2008 Irrigation theory and practice. In: *Soil- water-plant relationships and water requirement of crops and irrigation management.* Vikas publishing house, New Delhi. Pp. 421-548.

Murthy V V N 2009 Land and water management engineering. In: *Crop water requirements.* Kalyani publications, New Delhi. Pp. 243-247.

(Received on 31.07.2012 and revised on 08.11.2012)