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Laboratory Model of Automation in Agricultural Drainage

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ABSTRACT

Research in water management in the developed countries is progressing towards real time irrigation, decision support systems and expert systems. As the farm holdings are not large enough in India and also high cost of automation cannot be realized, low cost auto drainage, if developed and can be made availability to the farmers serves as a tool comfortable in view of the frequent power cuts and less power available in his farm. Based on simple electronic circuit principles of agricultural drainage, an attempt has been made to develop low cost auto irrigation and drainage based on soil moisture level or timer. Commercially available aqamon make single phase auto cut off and auto cut on circuit board fixed in a box along with sensors. This aqamon reversible circuit is used for agricultural drainage. The sensors in the auto drainage were kept at 0.2 m and 0.7 m height in the drainage well, if water level reaches beyond the cut off depth i.e.0.2 m from the bottom of the drainage well, the motor stops and motor stars at a depth 0.7 m from the bottom of the drainage wall. For the design of low cost automatic drainage circuit and it cost was Rs.350/- The device tested in the lab conditions almost similar to the actual filed conditions.

Key words : Auto agricultural drainage, Drainage well, Electrical circuits and Lab model.

The two notorious odds for crop growth are the excess of water and excess of salts in the soil. Subsurface drains remove the drain water in two methods namely gravity outlets and Pumped outlets. More drudgery involved in operating the agricultural pump sets as well as losses in excessive pumping.

In India nearly 9.38 million ha area is occupied by salt-affected soils out of which 5.5 million ha are saline soils (including coastal) and 3.88 million ha alkali soils (Michael A M and Ojha T P, 2009). Ground water surveys indicate that poor quality waters being utilized in different states are 32 to 84% of the total groundwater development. The state of Andhra Pradesh, situated on the eastern coast of India, with a total geographical area of 2,74,000 sq km is the fifth largest state, accounting for 8.4 percent of the country's area with a population of 121 million. The area affected by water logging and salinity in Andhra Pradesh is estimated to be 2.74 lakh ha and 1.15 lakh ha respectively in canal commands alone.

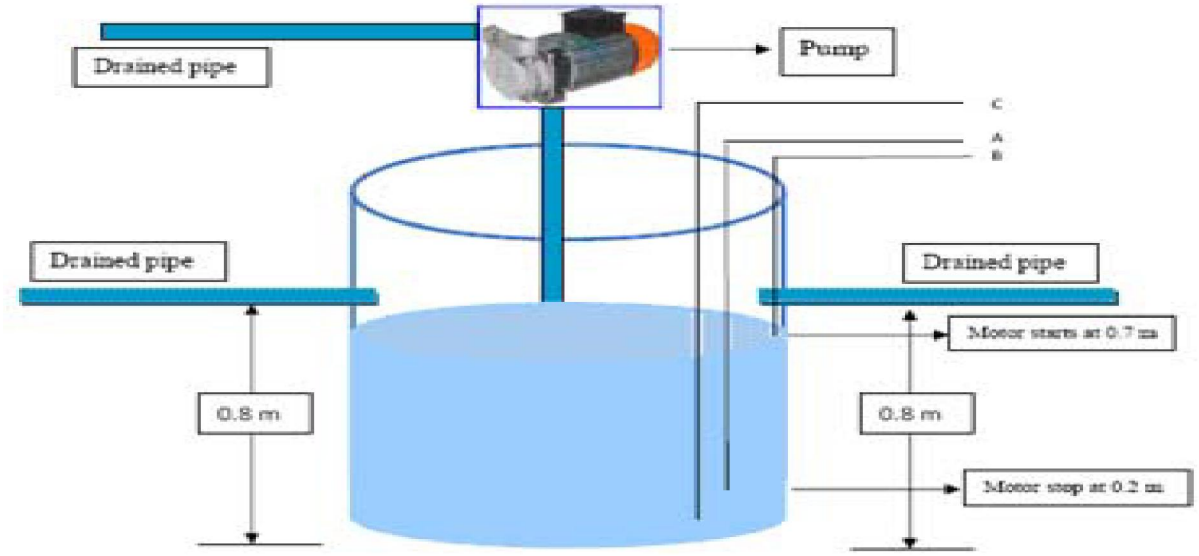
Auto-drainage is the method of removal excess water through pumped outlet automatically without interference of the man power. The rapid advance in electronics and its successful use in developing auto drainage system have made it possible it to practice efficient removal of excess water and saline water. Auto drainage can be done based on using some sensors controls and simple circuits connected to the starter of the pump set based on quantity of water to be drain(Aravind R, 2004). In the coastal areas of Andhra Pradesh, the single phase AC motors of 1-5 hp are commonly used for drainage. It is proposed to develop automation unit at low cost with the following objectives

1.To study the low cost devices and automation in agricultural drainage and research advancement.

2.Development of a device functioning underneath the soil that 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 drainage situations.

Fig 1. Laboratory model of automatic of pumped drain outlet



C: power supply terminal, A: upper sensor and B: bottom sensor

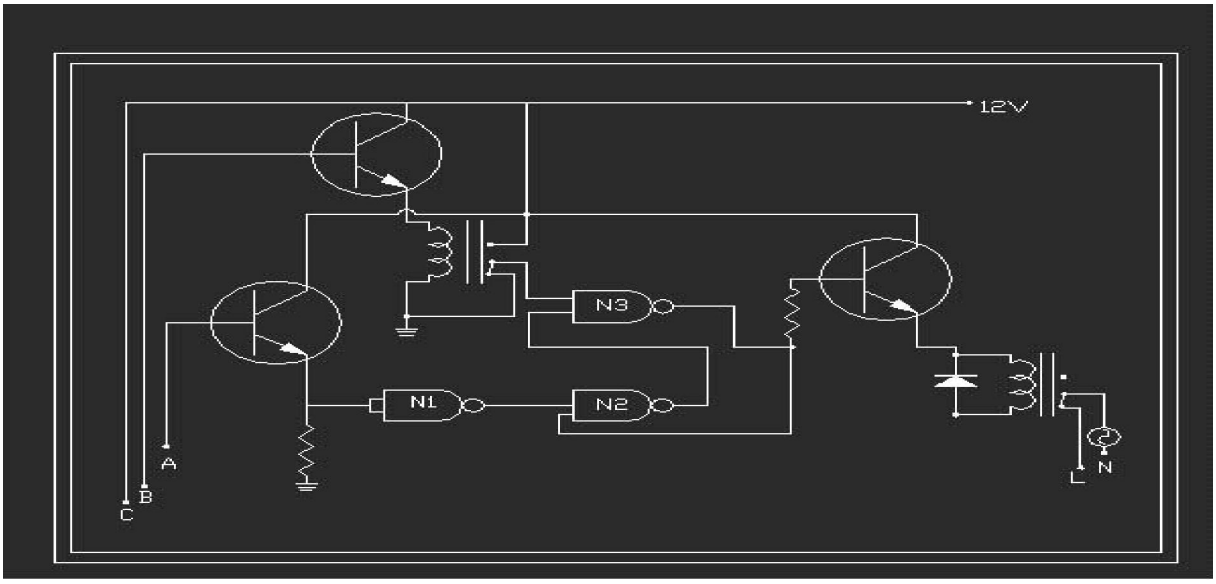
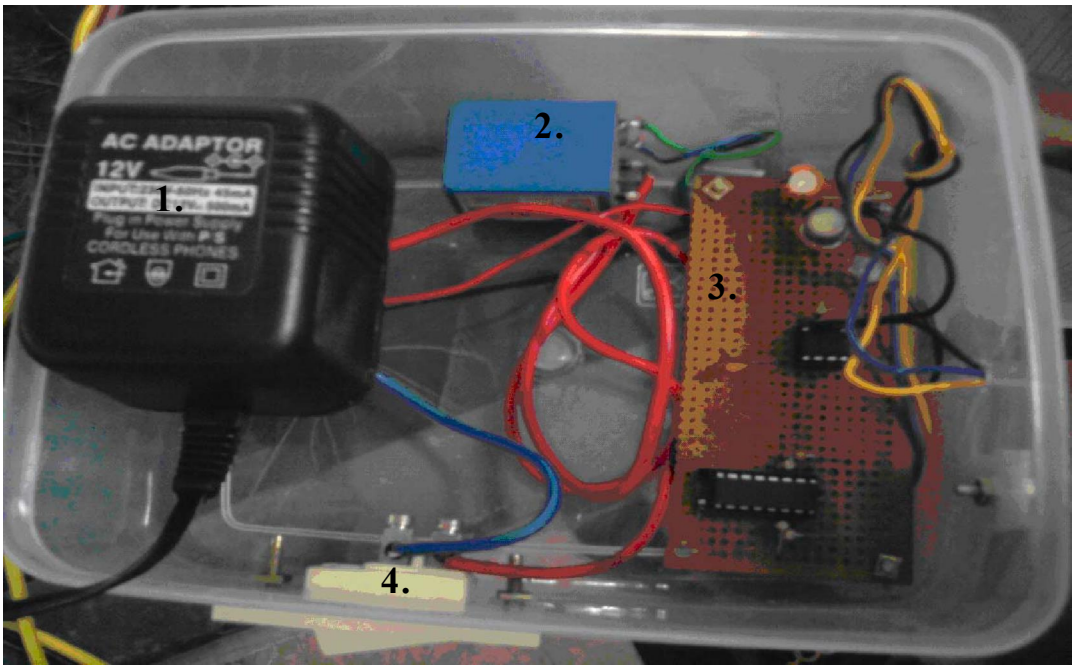


Fig 2. Circuit diagram of auto start and cutoff device for drainage

MATERIAL AND METHODS

Automation of Drainage

This experiment was conducted at hydraulic laboratory in College of Agricultural Engineering, Bapatla in the period of 2011.The auto irrigation concept can be extended to pump the outlet drainage, which will save the operators time and attention in switching on and off of the pump set. Hence two experiments namely auto irrigation and auto drainage are conducted in this study. For drainage experiment, the sensors are placed at two levels (0.7 m & 0.2 m, vertically in the drainage tank/well) for cut off and on for the drainage pump. As the experiment will take a large number of cycles with sand as bed for crop, the drain bed was filled with clay soil. Here the main concern is not the design of drainage system, but a low cost automation to reduce the drudgery of the operator of the drainage system. The experimental set up is shown in Fig. 1. Auto drainage essentially requires reversal of the circuit board used for auto-irrigation purpose. With little improvements in circuit board, the same automation unit can be prepared for higher sized pumps too, which are essential for agricultural purpose.



1. Adopter (230-12 volts) 2.Relay 3.Circuit board 4. On-Off Switch

Plate 1. Circuit of single phase of 0.5 hp motor for auto Drainage.

The sensors are fitted into the drainage well throughout its length at various heights as shown in fig.1 and connected to the circuit at appropriate terminals. Power supply terminal C is at the bottom of the tank, sensor terminal A is just above the bottom of the tank and sensor terminal B is at the top of the tank. When the water level in the drainage well touches the sensor B, the IC gets triggered then the relay (RL) gets energized and the motor starts pumping the water. As motor is pumping the water, the water level in the drainage well is decreased gradually. When the water level in the well falls below sensor A, the IC gets triggered, then the relay (RL) gets de-energized and the motor stops work. Again, when the water level in the drainage well touches sensor B, the cycle repeats and auto drainage circuit was shown in fig 2 and plate 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

Test results of the laboratory model of low cost auto drainage were presented in table 1. Initially, the water level is above 5 cm from the soil surface of paddy field, and then the water infiltrated in to the soil and drains the excess water through the nylon mesh pipe (32 mm).

Measurement of volume of percolated water outflow

Volumetric measurement by arranging a 40 litre 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 and also total volume of water discharged is also calculated and shown in table 2

Table 1. Average discharges through irrigation pump used for the study.

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

Average Discharge of the irrigation Pump (Q) = 0.8040 Ls^{-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.

Table 2. Drainage of percolated water in the mobile paddy bed.

Time (min)	Volume of Drainage water (L)
00:00	0
00:15	2
00:30	4.5
00:45	7.5
01:00	4.5
01:15	5.5
01:30	6
01:45	4
02:00	5.5
02:15	3.5
02:30	Irrigation started

and fig. 3. This would help in water balance studies if required for the further studies.

Total Volume of Drainage water = 43 L

Total quantity of water retained by the soil column of paddy filed
= Total volume of water applied for Irrigation - Total Drainage
= 70.75 – 43
= 27. 75 L.

Cost analysis

Design the low cost automatic drainage circuit with the cost of Rs.350/- The cost of automatic drainage circuit is presented in table 3.

Conclusions

The following conclusions were drawn,

1. 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 subsurface drainage systems. This type of low cost device would definitely reduce the drudgery of the operators.
2. A laboratory mobile paddy bed field with drainage system was installed to drain the water into a drainage well which was equipped with automatic drainage circuit and tested for automatic motor switch on- off for maintaining proper water level.
3. This automation would save the farmers not only from the snake bites during night times as is common in villages, but also they increase the life of the motor.
4. For laboratory study purpose 0.5 hp motor was used and the developed low cost soil moisture sensor with cost of Rs.350/-.

Fig 3. Drainage of percolated water in the mobile paddy bed.

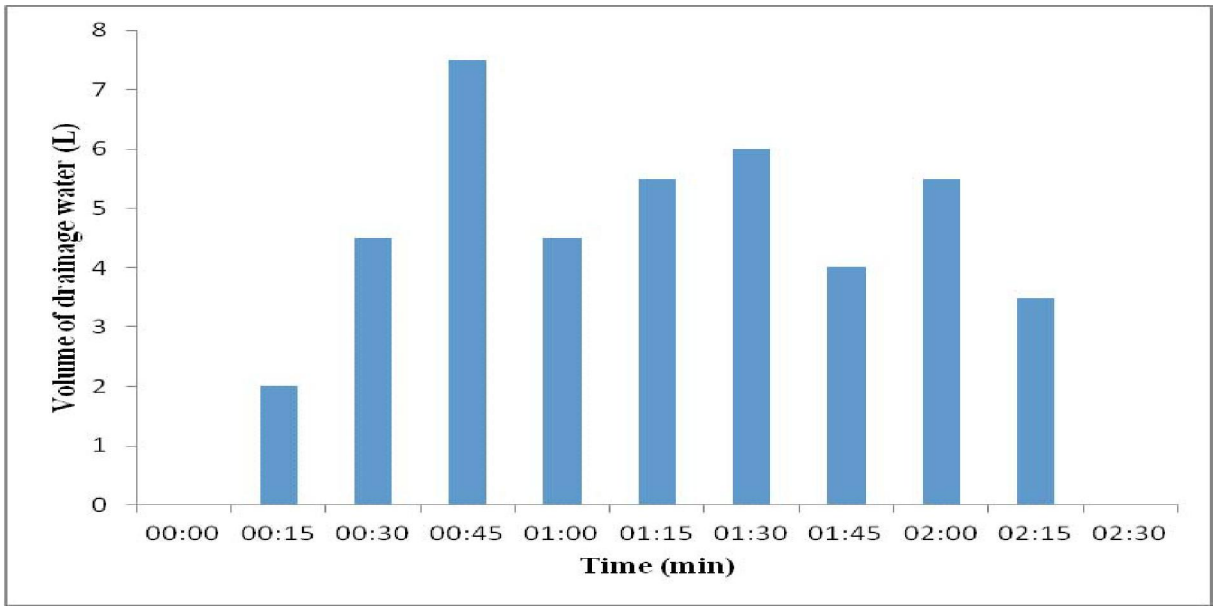


Table 3. Details of different parts used in the on-off switch circuit for Drainage and their price

S. no.	Name of part	Specification	No. of units	Price per unit (Rs)	Total price (Rs)
1	Adapter	0-12 V	1	100	100
2	Capacitor	1000 µfd	1	15	15
3	Capacitor	100 µfd	1	5	5
4	I.C(integrated circuit)	CD4011	1	25	25
6	Electromagnetic relay	12V	1	70	70
7	On-off switch	6Am	1	10	10
8	Flexible wire		1 packet	10	10
9	Connectors or sockets	Plastic	2	5	10
10	Soldering lead	west-X	1 bundle	5	5
11	Paste		1 bottle	5	5
13	Covering box	Plastic	1	25	25
14	Servicing charges	——	——	——-	70
				Total	350/-

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