The implementation of optimized drip irrigation system based on semiconductor sensors

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Abstract. This article presents an optimized version of a drip irrigation system based on semiconductor sensors. In this study, the organizational parts of the drip irrigation system based on semiconductor sensors are fully automated, namely: control of the water base, water volume in the pipe, water velocity in the pipe, soil moisture, salinity, temperature, ph of hydrogen content in the soil, pressure regulator valves. The electrical properties of a drip irrigation system based on semiconductor sensors have been proven, on the basis of which a semiconductor material can achieve an optimal result. The system provides economic indicators for one hectare of land and an analysis of the complete replacement of imported products.

1. Introduction
At present time, with the rapid development of technical and economic indicators of agriculture, the need for water is growing. Due to that, in order to save water, the system of drip irrigation of agricultural lands has been widely introduced. Examples include countries using drip irrigation and their performance. These days drip irrigation is used in many countries on earth, where water resources are limited and absent. In the world, more than 1.2 million hectares of land are irrigated by drip irrigation (USA - 888 thousand hectares, Spain - 34 thousand hectares, Israel - more than 100 thousand hectares. Australia - about 50 thousand hectares, Italy - 32 thousand hectares, France - 20 thousand hectares, China - 20 thousand hectares, South Korea - 15 thousand hectares). For example, in the State of Israel, the crop irrigation is carried out in 100% pressure system, that is, drip irrigation, which works under pressure generated by pumping stations, sprinklers and other water resources that can be used sparingly [1].

A number of scientific investigations have been carried out on drip irrigation system, for example: Russian scientists Yasonidi O.E. [2], Markov Yu.A. [3], scientist of the Crimean Federal University V.N.Storchows. [4,5], from Volgograd scientists. Professor A.D. Akhmedov, A.A. Temerev, E.Yu. Galiullina, from Republican scientists M.Kh. Khamidov, Kh.I. Shukurlaev, A. B.Maksamataliev [6], A.G. Bezborodov, G.A. Bezborodov [7], R. Bakiev [8], Z.A. Artukmetov, M. Shodmanov [9], Z.A. Artukmetov, Kh.Sh. Sheraliev [10], Z.A. Artukmetov, Kh.N.Allanov [11], Sh. Azizov [12], M. Khamidov, X.I. Shukurlaev, I. Begmatov, A. Mamataliev [13], R.T.Gazieva, A. M.Usmonov, E. O.Ozodov [14], S.A. Mamatov [15], Kh.T. Rakhimov [16], A. M.Arifdzhanov, A.M.Fatkhullaev, K. T.
Rakhimovs works provide examples about the convenience and operation of drip irrigation systems, but the automation process has not been fully proven, our studies show that the irrigation process of one hectare land in an automated system is optimized without intervention human, soil moisture, temperature, salinity and by the difference of the amount of ph from distance. Definitely, a drip irrigation system is the irrigation network designed to deliver the necessarily amount of water equal to the water of plants to its root layer. The difference between drip irrigation and other irrigation methods is that water is distributed evenly over the field according to the needs of crops. The sown areas of the field are uniformly moistened. No excess moisture appears in the soil. When watering, the moisture in the soil exceeds the required amount and the crop is immersed in water, and between watering the soil dries out and the plant remains without water. Consequently, due to the result, the plant uses its energy to overcome these cases. With drip irrigation, the moisture content of the root layer of the crop is kept constant and the plant uses all its energy to create its own crop. Studies show that with drip irrigation the soil moisture permanently suits the needs of crops [18].

2. Methods and Results
General diagram of a drip irrigation system. A drip irrigation system usually includes the following elements:
• water source (sink, pool);
• pumping device;
• device for preparing fertilizer solution and adding it to water;
• water treatment (filtering) equipment;
• trunk and distribution pipelines;
• devices connecting parts of the system;
• pressure regulators;
• drip hoses;
• control and measuring equipment.
The research results were obtained for one hectare of land; Figure 1 shows the diagram of drip irrigation system.

Figure 1. Diagram of the drip irrigation system: 1 - photo relay for opening and closing water; 2 - green LED indicating that water base is full; 3 - red LED indicating a decrease in the water base; 4 - device for preparation of fertilizer solution (Venturi injector); 5 - sand filter and device for determining the water pressure in the pipe; 6 - device for determining the speed of water in the pipe; 7 - light-emitting diode transmitting plant dehydration to the water base; 8 - thermo hygrometer for determining soil moisture and temperature; 9 - device for determining the ph of soil; 10 - pressure regulator valves (dripping)
2.1. Drip Irrigation System Components

Figure 2 shows a circuit of a photo relay that automatically opens and closes water: where photo resistor PR<sub>1</sub> transmits data to K1-relay for turning on and off when a crack signal is received, resistor with value of R<sub>1</sub>-10k, NPN-based on VT1-silicon and VT2- silicon based on P-N-P KT3107 transistor based on PNP serves as a signal amplifier, K1.1 - a switch.

![Figure 2. Drawing of the water relay opening and closing relay](image)

It is clear that Figure 3 shows the LED diagram in the mode based on liquid permeability, this diagram serves to perform a function showing the decrease and filling of water in the base.

The current photosensitivity of the photocell of the drip irrigation device - polarons based on CdS single crystals is 10<sup>5</sup> A/W when irradiated with light with a wavelength of λ = 510 nm (radiation power 2·10<sup>-8</sup> W/cm<sup>2</sup>, bias ~ 1 V, dark current 5·10<sup>-10</sup> A). This is significantly higher than that of the known semiconductor polarized radiation analyzers. A significant change in the value of pleochroism (from –0.9 to +0.8) with a change in the wavelength from 515 to 508 nm can be used to accurately determine the wavelength of monochromatic radiation in this range.

The main advantage of photocells (PC), a drip irrigation device based on CdTe and CdS structures, is that all these structures have thin dielectric layers - oxide films - between metal contacts and a semiconductor. Such structures compare favorably with other PCs in that such PCs are based on the redistribution of an external applied voltage due to modulation of the base resistance caused by the generation of electron-hole pairs and their uneven distribution under the influence of electromagnetic radiation. Such semiconductors based on photocells represent two alternating regions with different concentrations of traps and such levels of compensation that, without illumination at the interface between the regions, the height of the potential barrier does not exceed several kT. When such structure is illuminated by light from the region of intrinsic absorption, a potential barrier appears at the interface, the height of which can significantly exceed kT, and the field strength in the barrier can reach 10<sup>5</sup> V/cm and more. The current photosensitivity of such photocells can exceed one electron per photon, i.e. the structure with such barrier has internal reinforcement. It should be noted that broadband PCs made on the basis of Al<sub>B</sub><sup>6</sup> semiconductor compounds and their solid solutions have the above property, in probability. This is explained by the fact that, firstly, they are created on the basis of wide-band compensated semiconductors or solid solutions based on them, in which E<sub>g</sub> changes smoothly or abruptly and a potential barrier is formed between the layers. Secondly, in each composition of the solid solution, impurities can be distributed in homogeneously, since each of them is a wide-gap compensated semiconductor, which also leads to the appearance of potential barriers in the base of the PC. This is probably why such PCs created on the basis of highly compensated CdS films and CdS<sub>x</sub>Te<sub>1-x</sub> solid solutions have record values of current sensitivity, and therefore we chose such PCs to create our drip irrigation devices.
As given in Figure 4, injectors take a small portion of concentrated fertilizer solution from a stock tank and inject it into the water line. In the recent studies, the device for preparing fertilizer solution (Ventura injector) (a), water pump 12 V was used [6]. A filter that purifies water in a pipe and a device that determines the pressure of water in a pipe, in one part. The spinner is designed to control the full water supply to the entire pipe section. Optoelectronic switch that transfers the dehydration of the plant to the water base was useful to further study.

Undeniably, one of the most important soil indicators is ph. The Ph is the indicator of hydrogen, which indicates the concentration of free hydrogen ions in water. To simplify this concept, ph is determined from the quantitative ratio of N⁺ and ON⁻ in water. For example: if there are many N⁺ ions in the water, the acidity of water will be higher. The higher the content of ON⁻ ions, the higher the alkalinity of the water.

It is essential to note that the pH level tends to rise spontaneously. In distilled water, these ions balance each other. In such cases, water pH = 7, i.e. neutral.
The acidity or alkalinity of the soil is directly related to its agrochemical properties and plant development.

Acid plays a key role in providing plants with nutrients. Vegetable crops grow very hard on soils with high acidity or alkalinity. Hence, it is unreasonable to expect high yields on such soils. High (pH > 9) or low (pH <4) soil pH is toxic to the roots of your plant.

In soils with optimal acidity, plants can easily absorb nutrients or mineral fertilizers, and the physical properties of soil are improved.

In soils with high acidity pH = 4.0-5.5, the following cases are observed:
• Iron, manganese are easily absorbed, but their concentration reaches toxic levels.
• Phosphorus, potassium, sulfur, calcium, magnesium and molybdenum are poorly absorbed.
• Plants are susceptible to disease and insect attacks.
• The activity of microorganisms stops.
In soils with increased alkalinity, pH > 7.5, the following cases are observed:
• Iron, manganese, phosphorus, copper, zinc, chalk and most microelements are difficult to assimilate.
• Reduced capillarity, water permeability and filtration properties of the soil.
• pH control.

Phosphoric acid is used to lower pH of nutrient solution, and potassium hydroxide to raise it. Or you can use the table from Table 1 below [17]:

| Lower pH          | pH Raises         |
|-------------------|-------------------|
| Phosphoric acid   | Potassium hydroxide |
| Sulfuric acid     | Potassium carbonate |
| Nitric acid       | baking soda       |
| Lemon acid        | N/A               |

A device for determining soil pH is shown in Figure 5.

![Figure 5. Device for determining soil pH](image)

It is interesting to note that irrigation Hoses and Droppers Drip hoses are used to supply water from the distribution pipe to the plant root according to the needs of plants. Drip hoses are made of polyethylene and depending on the water consumption, in most cases there is a diameter of Ø 16 mm and Ø 20 mm or Ø 12 mm in some cases. In practice, drip hoses are used as types of drip hoses that can be installed by cutting the hose.

For the connection of elements of drip irrigation system to each other, different types of connecting parts are used (angular, triple, connector, valve, etc.). Pressure regulator (dropper) valves are shown in recent studies [19].

The cost of building of the drip irrigation system. The cost of introducing a drip irrigation system depends on the specifics of the construction site and the type of crops. The cost of implementing a drip irrigation system in a garden planted according to the 4x2.5 m scheme is shown in Table 2.
Table 2. The cost of implementation of the drip irrigation system

| Device and cost type                               | Amount | Price |
|---------------------------------------------------|--------|-------|
| Territory of a modern garden                      | 5 ha   | N/A   |
| The scheme of planting saplings 4x2.5 m           | 1 ha   | 1000 type | N/A |
| 1. Pool cooler                                     | 1 type | 1.0   |
| 2. Water pump with K25/32 mark                    | 1 type | 4.5   |
| 3. Disc filter (with net)                         | 1 type | 2.2   |
| 4. Fertilizer device (“Venturi”)                  | 1 type | 1.0   |
| 5. Trunk pipe d=63m                               | 300 m  | 3.4   |
| 6. Distributing pipe                              | 500 m  | 2.6   |
| 7. Irrigation hoses d=16m                         | 12500 m| 10.0  |
| 8. Drovers (4l/hour)                              | 10,000 | 2.8   |
| 9. Assisting and connecting parts                 | N/A    | N/A   |
| 10. Construction materials                        | 30%    | 9.3   |
| 11. The cost of preparing project                 | N/A    | N/A   |
| Totally                                          | 5.0 ha | 40.3  |

Note: The cost of the drip irrigation system depends on the tree planting scheme and based on its optimal design, construction costs can be reduced by almost half.

The benefits of drip irrigation “Drip irrigation saves 20% to 80% of water compared to other irrigation methods, depending on the type of crops. Drip irrigation irrigates crops, but not fields.” The ISMITI survey results are presented in Table 3.

Table 3. The results showing the benefits of drip irrigation are from the ISMITI study

| The place where the research was carried out | Type of crops | Water saving,% | Resource (reducing fuel, labour), % | Increasing yield,% |
|---------------------------------------------|---------------|----------------|-------------------------------------|-------------------|
| Namangan district                           | Garden        | 60             | 25                                 | -                 |
| Uychi district                              | Cotton        | 65             | 60                                 | 90-156            |
| Fergana region                              | garden        | 32             | 25                                 | 108               |
| Fergana district                            | (peaches)     |                |                                     |                   |
| Kashkadarya region                          | Vineyard      | 30             | 30                                 | 25                |
| Kitob and Nishon districts                  | Cotton        | 35             | 50                                 | 59                |
| Karakalpaxtan Republic                      | Tomato        | 54             | 60                                 | 65                |

The yield increases and the quality of the crop improves. The yield increases up to 40% in orchards and vineyards, up to 80% in vegetables. Table 4. The harvest leads to early ripening for 10-15 days.

Table 4. Productivity results

| Type of crops     | Measuring unit | Medium yield          |
|-------------------|----------------|-----------------------|
|                   |                | Simple irrigation     | Drip irrigation   |
| Cotton            | c/ha           | 25-30                 | 50-55             |
| Onion             | c/ha           | 50-60                 | 100-120           |
| Corn (grain)      | c/ha           | 6-7                   | 25-32             |
| Tomato (in open place) | c/ha       | 25-30                 | 130-140           |
| Grape             | c/ha           | 20-25                 | 45-50             |
| Apple             | c/ha           | 10-15                 | 55-60             |
| Apricot           | c/ha           | 4-5                   | 15-16             |
| Peach             | c/ha           | 5-6                   | 18-20             |
| Potato            | c/ha           | 20-25                 | 45-50             |
From the given information it is understandable that the use of drip irrigation technique is significantly reduced. This technique is not used because the soil is not loosened and fertilizers are applied with water. The field is not cultivated, ditches are not used. Typically, the tractor enters the field 25-30 times, and with drip irrigation only 6-7 times. About 50-60 liters of diesel fuel per hectare are saved during the season. With drip irrigation, fertilizers are consumed much less frequently: With drip irrigation, the cost of year-round fertilizers is reduced by 30%! The cost of fertilizers applied during the growing season has been reduced by 50%. The absorption of fertilizers by plants exceeds 90% and usually does not exceed 30-40%.

3. Conclusion

By summarizing it is important to suggest that drip irrigation significantly reduces labor work, since there are no ditches on the field, so the irrigator does not need to monitor the water, prepare the field for irrigation, that is, grass, cellophane and other equipment, only one irrigator can easily irrigate 10-20 hectares per day. Its labor productivity increases significantly. The number of swimmers is significantly reduced. In swimmers, the frequency of occupational diseases (boils, radiculit, etc.) is significantly reduced. Land use efficiency is increasing. Crops are also grown in land that remains at the edge of the field due to the lack of tractors in the field. Water is not discharged from the field, as a result, the need for ditches is sharply reduced, the soil of the field is not eroded, the fertile soil layer is preserved, weed seeds do not fall into the field, since the water is filtered, the field does not overgrow. Soil re-salinization is reduced, excess water is not used to irrigate crops, and groundwater level does not rise. Seasonal soil salinization does not occur in fields with low groundwater levels. In winter, it is not necessary to wash the soil that has not been salted during the season. By reducing the salinity of soil leaching, costs for water, equipment (floor removal), labor work (saline washing) are reduced. In areas with low salinity, excavation of foundation pits is reduced. In vertical well areas, pump performance is reduced, resulting in significant energy savings. Local manufacturers of elements of drip irrigation systems SUE "Shurtangazkimyo" (Kashkadarya region) produces polyethylene granules, pipes, hoses, drip tapes, components. Pipe Technologies (Tashkent) manufactures pipes, irrigation hoses, drip tapes, accessories and drippers. Exim plast (Tashkent) manufactures pipes, drip hoses and accessories. LLC "Santexplast" (Tashkent) manufactures components, filters and fertilizers. Private enterprise "Agroplast installation service" (Uychinsky district of Namangan region) produces pipes, hoses, accessories and bends. OOO "Spetspolymer" (Tashkent) produces pipes, irrigation hoses, accessories and droppers. Scientific and Consulting Center "Water-saving irrigation technologies" (Tashkent). The center conducts research to improve the use of water-saving technologies, develops proposals and recommendations, provides specific advice and projects. The center is the main organization that provides consulting services for the implementation and development of drip irrigation systems.

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