# APPLIED THE ANALOGUE SYSTEM IN DRIP IRRIGATION SYSTEM (LOOPED WITH CARRIER NETWORK)

**Eman Mehdi Al-Mousawi**
**Assistant lecturer Engineering College**
**University of Babylon**

## ABSTRACT

Drip irrigation system can apply frequent and small amounts of irrigation water at many points of a field surface/subsurface near the plants with drip irrigation, plant water and fertilizer requirements can also be applied to the plant root zone with minimum losses, maintaining steady moisture in the soil profile. In addition, drip irrigation systems have the advantage of fitting difficult topography. The research studied drip irrigation system (looped with carrier network) in analogue system, to generate data by using analogue system, it an electrical board is constructed to simulate the field network. That means to use thermal wires to simulate the laterals, and resistances to simulate the emitters. A relationship has been concluded through the derived equation between the emitters discharge and resistance voltage. Comparing both equations that are derived from the field, a new relative equation has been concluded; with a new relative reflect the head and current relationships. The analogue results confirm the field results by using three types of emitters (Turbo, Adjustable flow drippers and Long-Path emitter). The field results took from studied at 2010.

**Keywords: Drip irrigation, Pressure, Analogue, Emitter, Manufacture coefficient**

# تطبيق نظام المحاكاة الكهربائي على نظام الري بالتنقيط (للشبكه المغلقه مع خط ناقل)

## الخلاصه

نظام الريّ بالتنقيط هواضافة كميات صغيره ومتكرره من الماء الى الحقل و نظام الري بالتنقيط يغطي معظم نقاط الحقل فوق وتحت سطح التربه قرب المنطقه الجذريه بحيث تبقى التربه رطبة ضمن المنطقه الجذريه كذلك ان نظام الري بالتنقيط يوصل

الماء الى النبات بأقل خسائر من ناحية كميات المياه مقارنه بنظم الري الاخرى كما ان نظام الري بالتنقيط ملائم للاراضي ذات الطبوغرافيه المختلفه. تناول البحث تطبيق نظام محاكات كهربائي على نظام ري بالتنقيط (حلقي مع خط ناقل) لتوليد البيانات حيث تم تمثيل الشبكه الحقليه من خلال عمل لوحه كهربائيه بربط يحاكي ربط الشبكه الحقليه بأستخدام اسلاك حراريه لتمثيل خطوط المنقطات واستعملت المقاومات الكهربائيه لتمثيل المنقطات وتمت قراءة فروق الجهد والتيارات ومن خلال تشبيه التصاريف بفروق الجهد والضغوط بالتيارات تم استنتاج علاقه تربط بين الضغط في الشبكه الحقليه والتيار في اللوحه الكهربائيه من خلال معادله لكل نوع من انواع المنقطات الثلاثه المستخدمه حيث اخذت البيانات الحقليه من دراسه سابقه في 2010.

الكلمات الداله:ري بالتنقيط, ضغط, التمثيل, منقط, معامل المصنع.

## SYMBOLS

q: The discharge of emitter ($L^3$/T).

a: A coefficient specific to each emitter,

h: The pressure at the emitter (L),

x: An exponent depends on the flow regime,

V= Voltage in the resistor (volt),

I= Current in the resistor (amber)

b, y = constants

R.v.v= relative variation of Voltage

R.v.q= relative variation of emitter discharge.

## INTRODUCTION

Drip irrigation (also known as trickle irrigation, micro-irrigation, or low-volume irrigation) offers an excellent alternative to sprinkler irrigation for vegetable and small fruit growers. Trickle irrigation systems typically use 30-50 percent less water than sprinkler systems and the water are rationed to the plants as they need it. This reduces evaporation, particularly on hot, windy days, and enables the grower to only water the desired plants and not the row alleys or roadways. Weed control is therefore simplified, and workers are able to do fieldwork while the irrigation system is running. The system's almost continuous operation at low flow rates and operating pressures allow the grower to irrigate with lower-cost, smaller pumps through smaller, lightweight pipes which may deliver as little as 15 or 20 m3/m. The irrigation pumping requirement drops from the 7 to 4 m3/m per m2 at 50 to 40 psi typical for sprinklers to 5 to 2 m3/m per m2 at 20 to 6 psi for trickle irrigation systems. So 0.06 m3/m capacity water well solely dedicated to supplying 3 to 4 sprinklers may be used to trickle irrigate 2 to 4 acres of vegetables or small fruits, with enough extra capacity to meet normal household needs **[Robert A. Schultheis, 2005]**. According to **[Mizyed etal, 1989]** drip irrigation system efficiency depends on application uniformity. In surface drip irrigation systems, uniformity can be evaluated by direct measurements of emitter flow rates. The main factors affecting drip irrigation system uniformity are: (1) manufacturing variations in emitters and pressure regulators, (2) pressure variations caused by elevation changes, (3) friction head losses throughout the pipe network, (4) emitter sensitivity to pressure and irrigation water temperature changes, and (5) emitter clogging. (Similarly and Scicolone, 1998).

## HYDRAULICS OF SUB-UNIT

Polyethylene tubing 25mm in diameter and larger is commonly used for trickle irrigation mainlines and sub mains. Sizes of 25mm and less are used for laterals and micro-tubes. In order to achive optimum uniformity of emitter discharge, it is essential that the frictional head losses in laterals and mains be properly evaluated. The primary sources of head loss are pipe friction and losses caused by the emitter barbs **[Madramootoo, 1981]**.

**[Bralts et al, 1981]** showed that the hydraulic and manufacturing variation of emitters can be statistically combined and included in the design equations for uniformity of single chamber drip irrigation laterals. **[Al-Misned, 2000]** found the estimation of energy losses due to emitter’s connection in trickle irrigation laterals was very important. Since these losses had a direct effect on trickle irrigation system design, the study of these losses would lead to the improvement of system efficiency which would eventually result in conservation of water and energy. In his study, the problem of a lateral pipe with equally spaced emitters and uniform slope was evaluated. A computer program for estimating lateral discharge, emitter discharge and pressure head distribution along a lateral was developed. Individual emitters were considered in discharge and pressure estimations along the lateral starting from the downstream reach of the pipe. The friction head loss between successive emitters was estimated using Darcy-Weisbach, s formula. The change of the velocity head, the changes of momentum along the lateral, and the loss due to emitter were also considered. As the emitter discharge and energy losses were evaluated, the corresponding pressure head at each emitter was estimated accordingly. The output results from the program were in close agreement with the experimental data obtained from published work. The program provides a simple and direct method to design trickle laterals taking into account all energy losses including emitter’s connection losses.

## EMITTERS

A rather exhaustive classification of emitters, their hydraulic and mechanical properties, and details of their construction are given by **[Krystal and K. Zanker, 1974]**, **[Keller and Karmeli, 1975]**. Emitters can be classified according to any one of several main characteristics. Three categories were defined by **[Krystal and K. Zanker, 1974]**: orifice drippers, long path type of drippers, porous tubing. Emitters are usually classified by the method in which they dissipate pressure or discharge characteristics **[Keller and Bliesner, 1990]**.For example, there are long path, vortex, orifice, flushing, continuous flushing, and multi-outlet emitters. [Solomon, 1979] stated that the efficiency of trickle irrigation systems depends on the uniformity of emission rates throughout the system. An important factor affecting this uniformity is the unit-to-unit variation between emitters. The design of an emitter, the materials from which it is made, and the care taken in the manufacturing processes affects the amount of such unit-to-unit variation that may be expected.

**[VanceLeo, 2004]** evaluated the application uniformity of subsurface drip distribution systems and the recovery of emitter flow rates. Emission volume in the field and laboratory measured flow rates were determined for emitters from three locations and studied the effects of lateral orientation with respect to slope on emitter plugging. Two different emitters were tested to evaluate slope effects on emitter plugging **[types Y and Z]**. The emitters were alternately spliced together and installed in an up and down orientation on slopes of 0, 1, 2, and 4% and along the contour on slopes of 1 and 2%. The emitters were covered with soil and underwent a simulated year of dosing cycles, and then flushed with a flushing velocity of 0.6 m/s. Initial flow rates for the two emitter types were 2.38 L/hr with a coefficient of manufacture (Cv) equal to 0.07. There was no significant difference in flow rates among slopes for type Y emitters, but there was a significant difference between the 1% and 2 % contour slopes for type Z emitters. Application uniformity of three different laterals at each site was evaluated. Sections of the lateral from the beginning, middle and end were excavated and emission volumes were recorded for each emitter. Application uniformity of laterals ranged from 48.69 to 9.49%, 83.55 to 72.60%, and 44.41 to 0% for sites A, B, and C, respectively. Mean emitter flow rates were 2.21, 2.24, and 2.56 L/hr for sites A, B, and C, respectively under laboratory conditions. Application uniformity under laboratory conditions ranged from 70.97 to 14.91%, 86.67 to 79.99%, and 85.04 to 10.01% for sites A, B, and C, respectively. A flushing velocity of 0.15 m/s with no chlorination, shock chlorination of 3400 mg/L and flushing velocity of 0.15 m/s, and shock chlorination of 3400 mg/L and flushing velocity of 0.6 m/s treatment regiments were applied to all laterals collected to assess emitter flow rate recovery to the nominal flow rate published by the manufacturer. All laterals showed an increase in the number of emitters within 10% of the published nominal flow rates.

## CASE STUDY

The main idea in this research is to generate data for drip irrigation system by using analogue system that mean simulate the field work in an electrical circle work with DC voltage .

## FIELD WORK LAYOUT

The water source is AL-Zabar Stream in Khagan Village in Babylon Governorate, 30:15:15 E, 44:40:30 N in the middle of Iraq and the maximum pressure level is 16m head. Water is provided by using a pump give a head of 20m with flow rate180 l/min). Behind the pump there is a filter (plastic filter type) and a valve to regulate and control the main discharge and main pressure head in the main line. The main line is a plastic pipe with 25mm diameter and one meter in length. The main pipe is divided into two manifold plastic pipes each is 25mm in diameter and 2.5m long. From the manifold two laterals with valves at the head and end of each lateral and there is air relief at the ends of the laterals. The lateral is polyethylene pipe 16mm in diameter and 15m long. The spacing between two laterals is 1.25m; the ends of the laterals are looped together by a polyethylene pipe 16mm in diameter. The main pipe connected with the looped pipe by carrier pipe. The main pressure gage is connected downstream the pump and upstream the controlling and regulating valve on the main pipe. Other pressure gages are connected at the head, middle, and the end of each lateral in the network. There are 13 gauges in total in the whole network. The traditional network is represented through the end valves enclosure while the proposed network is represented by opening the end valves. (**Figure 1)** and (**Figure 2)** shows the network at two cases, and the locations and numbers of the emitters and gages.

## ANALOGUE SYSTEM

Analogue techniques are potentially useful for data processing and for providing elements in instrumentation and control systems. The principle of studying a system indirectly by reference to an analogue system may be applied in a number of different ways. The relation between a system and its analogue is basically a mathematical one in which the set of equations that describes the interactions between various system variables is identical to the set of equations describing the interaction between corresponding variables in the analogue. The earliest analogue devices were based on mechanical system, in which the analogue variables were the positions of the shafts. The movements of these shafts could be amplified or reduced (multiplied by constant) by the use of simple fixed gearing; two variables could be added or subtracted by means of differential gears; integration was achieved by a ball and wheel assembly. Different problems were solved by adjusting the mechanical layout of the analogue system so as to satisfy the appropriate set of equations, but perhaps acceptable for a special-purpose model of a particular system. It is also possible to build an analogue system based on hydraulic or pneumatic principles, and for some applications special-purpose analogue models of these kinds have proved to be useful **[Wilkings, 1970].**

## ANALOGUE COMPONENTS

The components of electrical analogue in the case study are depicted (**Figure 3)** where the analogue system consists of:

1. Thermal wires (500 watts) to simulate the laterals where the power loss due to temperature in the thermal wires simulates the friction head losses in the laterals.
2. A power supply to simulate water supply.
3. A voltage regulator (1 volt) to simulate the valve in the main pipe used to regulate the discharge.
4. An ammeter to simulate the pressure gages.
5. Resistors (1 kilo ohm) to simulate the emitters.
6. Switches (on-off) at the ends of the lines of analogue to simulate the valves at the ends of the laterals (i.e. when switched off this state simulate traditional network and when switched on this state simulate looped network.
7. Equation $q = ah^x$ (1)

Simulates equation $V=bI^y$ (2)

Where:

q: the discharge of emitter $(L^3/T)$.

a: a coefficient specific to each emitter,

h: the pressure at the emitter (L),

x: an exponent depends on the flow regime,

V= Voltage in the resistor (volt),

I= Current in the resistor (amber), and b, y = constants

The values of b and y may be found by any statistic program, and in this research, SPSS program has been used.

## COMPONENT EMITTERS

From the field results found the emitters components for the three types of emitter that used in the research and (**Table 1)** showed the components values for equation (1)

## ANALOGUE RESULTS

The switches are on when the system is on the proposed network **(Figure 2)**, values of the constants in eq. (2) are: (b=10.774 and y=0.191), which are computed through using SPSS program. Comparing eq.(1) below which is relative to the hydraulic performance of the emitter, with the eq. (2), which is relative to the electrical behavior in the analogue system, then the relative equation from the previous both equations is:

Example: For emitter type I with (x=0.539and a=6.429):

$q = 6.429\ h^{0.539}$

$V=10.774\ I^{0.191}$

When q=V as a value can be found the equation

$h=rI^{P}$ (3)

$h=2.61\ I^{0.354}$

**(Table 2)** lists the relative constants in eq. (3) for the three types of emitters that have been used.

## ANALOGUE AND FIELD RESULTS

The average results are used to summarize the average relative variation in proposed system to compare the analogue and field results as listed in (**Table 3)**.

## DISSECTION THE RESULTS

From the field data and the results that generated by equation 3 that seen the variation of the discharges were at the range (7.36 to 8.44) that mean the relative error in discharge was small when use the analogue system and that variation was acceptable from the engineering approach .

## CONCLUSIONS

From the results that generated the following conclusions are drawn from this study:

1- The generated data near the field data with few errors.

2- The generated data can be used in the studies for irrigation system.

## REFERENCES

Al-Misned, Ahmed S., 2000"Effect of energy loss due to emitters on the design of trickle irrigation laterals", Soil Science King Saud University, Riyadh, Saudi Arabia.

Bralts, V. F., I. P. Wu and M. Gitlin, 1981 "Manufacturing variation and drip irrigation uniformity", Trans. ASAE 24(1): 113-119.

Jahad, U. A., (2010), Hydraulic comparison of the performance of irrigation drippers in traditional with proposed looped network, Unpublished M Sc Thesis, Department of Water Resources, College of Engineering, University of Baghdad, Iraq

Keller, J. and D. Karmeli, 1975 "Trickle irrigation design", Ed and publ. by Rain Bird Sprinkler Manufacturing Crop. , Glendora, CA91740.

Keller, J. and R.D. Bliesner, 1990" Sprinkle and trickle irrigation", New York: Van, 1990.

Krystal and K. Zanker, 1974 "Hydraulic and mechanical properties of drippers", In Proc. of the 2nd Int. Drip irrigation Congress. San Diego, CA.

Madramootoo, C. A., 1981"The development of trickle irrigation system for banana (MUSA SPP.) production in ST. Lucia", M. Sc. Thesis, College of Agricultural Engineering, University of Mc Gill, Canada.

Mizyed, N and E.G. Kruse, 1989 "Emitter discharge evaluation of subsurface trickle irrigation systems", Transactions of the ASAE, 32: 1223-1228.

Robert, A. Schultheis, 2005" Irrigation of vegetable and small fruit crops" Natural Resource Engineering Specialist, University of Missouri Extension.

Similarly, Capra A. and B. Scicolone, 1998 "Water quality and distribution uniformity in drip/trickle irrigation systems", J. Agric. Eng. Res., 70: 355-365.

Solomon, K., 1979 "Manufacturing variation of trickle emitter", Trans. ASAE 22(5): 1034-1038, 1043.

Vance Leo, 2004" Evaluation of the application uniformity of subsurface drip distribution systems ", M.Sc. thesis, B.S, Texas A&M University.

**Table (1):** Values of $x$ and a for used emitter (Jahad, 2010)

| No. of emitter | Type of emitter | a | x | $R^2$ | Type of flow regime |
|---|---|---|---|---|---|
| I | Orifice emitter | 6.429 | 0.539 | 0.86 | Turbulent |
| II | Adjustable mini bubbler flow dripper | 7.216 | 0.462 | 0.83 | Turbulent |
| III | Adjustable flow dripper | 5.256 | 0.601 | 0.89 | Turbulent |

**Table 2:** Values of (r) and (p) in equation $h=rI^{p}$

| No. of emitter | Type of emitter | **Analogue component** | |
|---|---|---|---|
| | | **r** | **p** |
| I | Orifice emitter | 2.61 | 0.354 |
| II | Adjustable mini bubbler flow dripper | 2.38 | 0.4134 |
| III | Adjustable flow dripper | 3.301 | 0.318 |

**Table 3:** Average relative variation comparison for analogue and field

| State | Analogue R.v.v.% | Field R.qv.% | | |
|---|---|---|---|---|
| | | Type (I) | Type (II) | Type (III) |
| Proposed | 8.17 | 7.36 | 8.44 | 7.60 |

Where:

R.v.v: relative variation of Voltage

R.v.q: relative variation of emitter discharge that calculated by equation 3

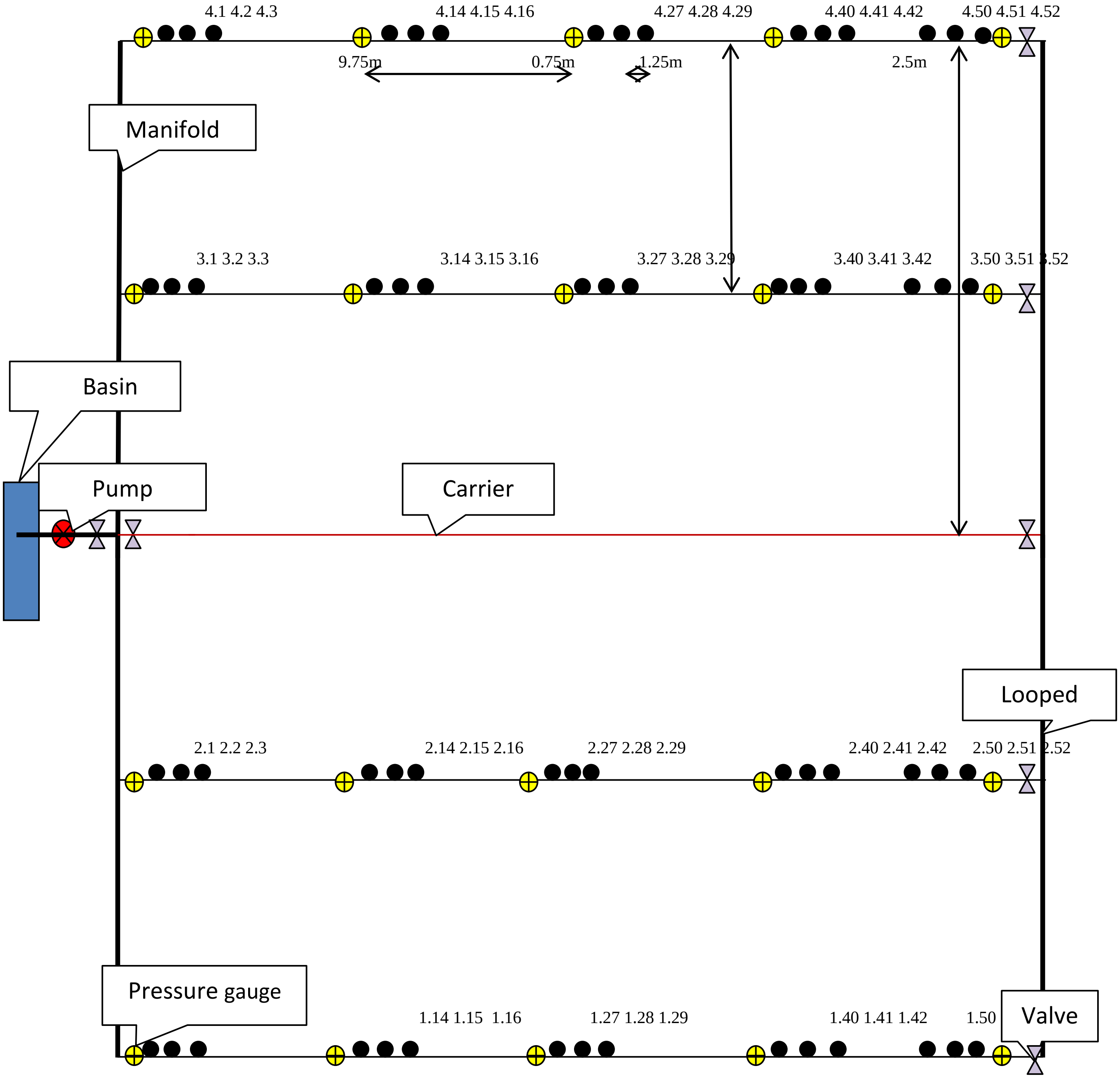

**Fig. (1):** System layout.

**Fig (2):** The field system.

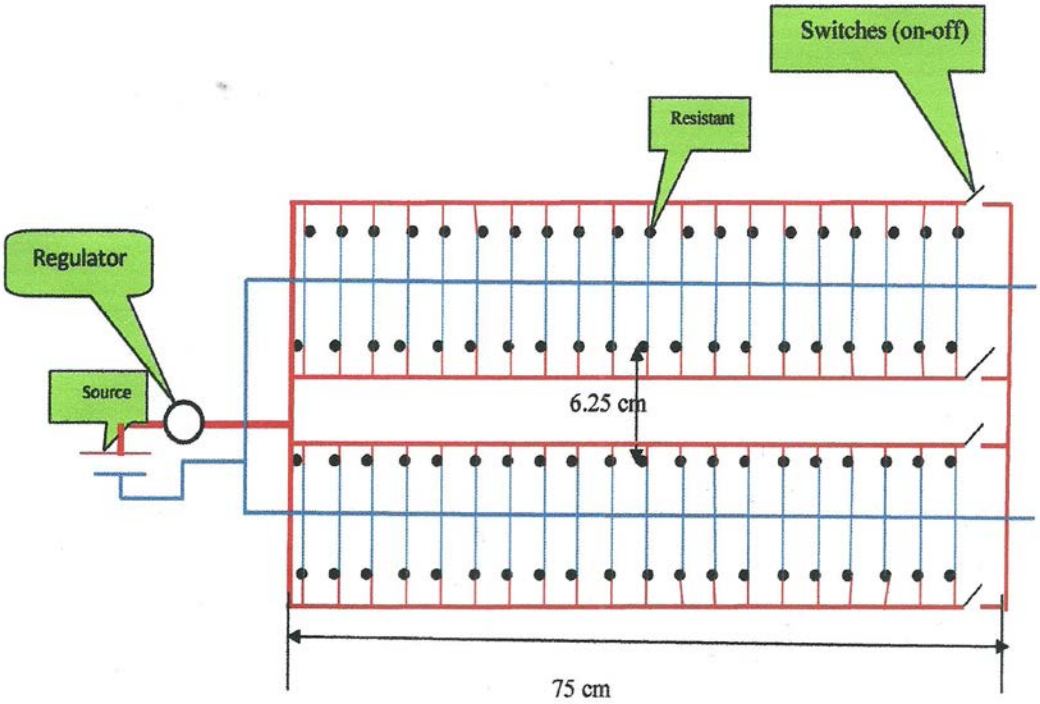

**Fig. (3):** The schematic analogue system