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DESIGN OF AN ELECTRONIC SYSTEM FOR DRIP EMITTERS ANALYSIS IN IRRIGATION SYSTEMS

DIEGO SCACALOSSI VOLTAN; JOÃO EDUARDO MACHADO PEREA MARTINS [1] AND ROGÉRIO ZANARDE BARBOSA[2]

[1] *Computer Science Department, School of Sciences (FC), São Paulo State University (UNESP), 17033-360, Bauru-SP, Brazil. E-mail: perea@fc.unesp.br.* Orcid iD https://orcid.org/0000-0003-1056-497X
[2] *Faculty of Higher Education and Integral Formation (FAEF), 17400-000, Garça-SP, Brazil. E-mail: rogeriozanarde@gmail.com.*

1 ABSTRACT

This work shows the design of a system for automatic monitoring of drip emitters in irrigation processes, which allows the counting of drops from an emitter and also the accumulated water weighing. Its main goal is to provide an electronic system for verification of drip irrigation uniformity, whose physical measured parameters can be sent to a computer through a direct cable or through a radio system that allows long distance monitoring.

Keywords: Drip irrigation, automation, uniformity

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2 RESUMO

Este trabalho mostra o projeto de um sistema para monitoramento automático de gotejadores em processos de irrigação, o qual permite a contagem do número de gotas de um gotejador e também permite a pesagem de água acumulada. O objetivo principal é fornecer um sistema eletrônico para verificação da uniformidade da irrigação por gotejamento, cujos parâmetros físicos medidos podem ser enviados para um computador diretamente através de um cabo ou através de um sistema de rádio que permite o monitoramento a longa distância.

Palavras-chave: Irrigação por gotejamento, automação, uniformidade.

3 INTRODUCTION

There are several Works, such as Ferdoush and LI (2014), Ferrarezi et al (2015), and Flores (2015) that demonstrate objectively the trend of technological electronic systems in agricultural area, which are based on the use of low cost devices,

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microcontrollers and wireless sensor networks. Microcontrollers are electronic components that include a complete computer architecture inside an only chip e allows the design of systems with low coast, small size and low power consumption. Wireless sensor networks are system where an electronic module that usually include sensor, a microcontroller and a radio transmitter are deployed on an area and allows its monitoring without cables, which becomes very interesting in agricultural uses. In this context, Pagan et al (2015) and Fernandez-Pacheco et al (2014) also emphasize the use of LabVIEW and ZigBee technologies, respectively. The LabVIEW is a high performance system that includes aspects of software and hardware for the fast development of sensing and automation system, while ZigBee is one of wireless sensor networks technologies that becomes popular due to its easy programing.

However its operation over time requires a control quality to ensure it efficiency (ANDRADE et al, 2017) and experiments proves that factors as pH, suspended solids, and total iron influences directly the clogging of drip emitters (SILVA, 2017), which becomes a very important element associated with the drip irrigation efficiency and reliability (ZHOU et al, 2017) (KHOSHRAVESH et al, 2018).

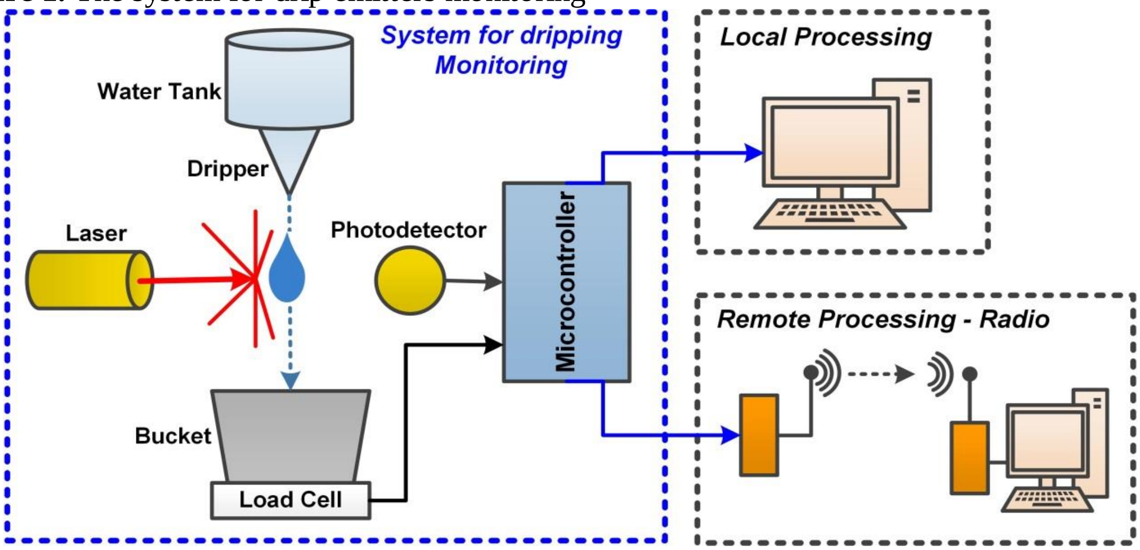
The technological trends above and the relevance of emitters clogging verification in drip irrigation processes have motivated the present work, which shows in the next sections the developed electronic system to verify atomically drip emitter uniformity over time.

4 METHODOLOGY

This work methodology is based on the detailed design, mounting and analysis of an automation system shown in figure 1, which is composed by a first module to counter the drop number from water tank and also to weigh the accumulated water in bucket which allows the accurate verification of both parameters over time.

The measurement results from the first module are sent to a computer through two possible ways that are either a direct cable or a telemetry system based on radio communication. The first data transmission process is indicated for uses in laboratories of irrigation analysis and the transmission thorough radio is indicated for applications in field where the deployment of several computers is impracticable over a long drip irrigation line.

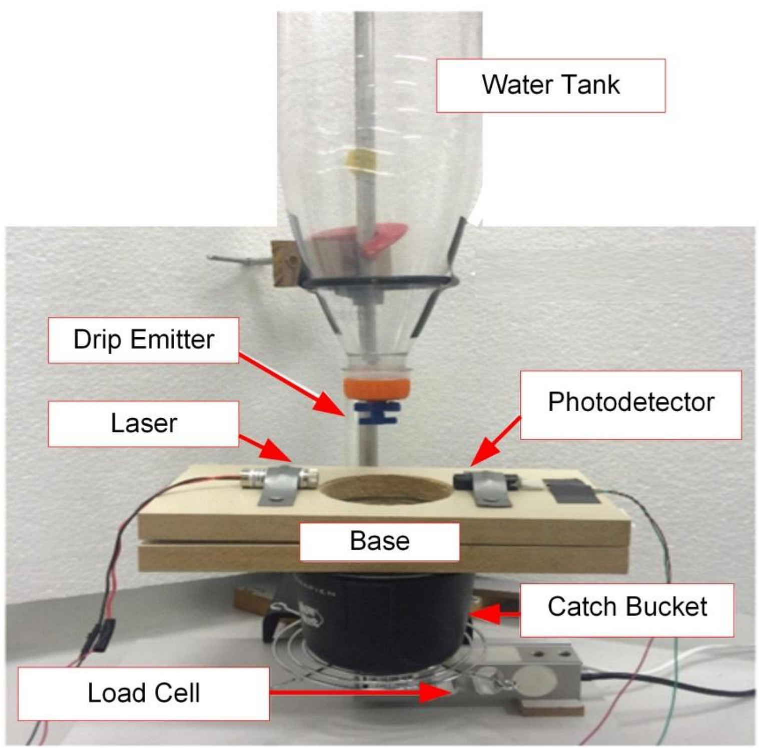
Figure 1. The system for drip emitters monitoring



5 RESULTS

Figure 2 shows the prototype of a system designed and mounted in this work to count the number of drops from a drip emitter and also to weight a bucket that catches the drops.

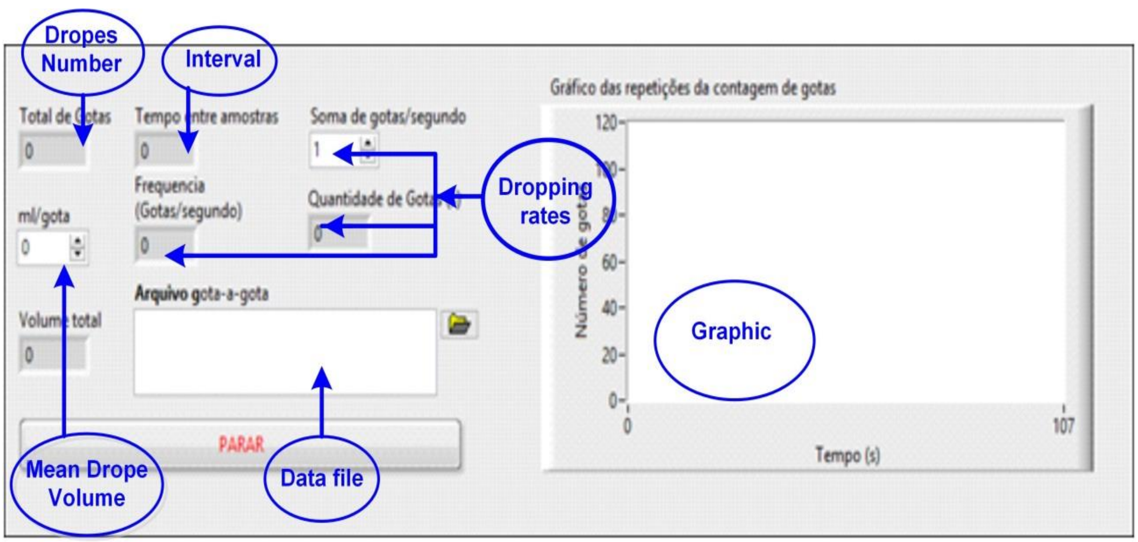
Figure 2. The real system experiment for drip emitters monitoring



The laser source operates with a power of 5mW and it actives a photodetector model TIL78 that becomes deactivated when the water drop falling from the emitter interrupts the laser light incidence on the photodetector, and therefore it allows the electronic drop detection. The TIL78 is connected to a microcontroller that receive a specific signal voltage level when occurs a laser ray interruption. It is a very simple hardware that was analyzed in this work with two different microcontrollers that are the PIC16F873, and an Arduino board model UNO. The model PIC16F873 presented an advantage of low power consumption at 1μA in standby mode operation that is mostly important for fields operation when the power supply is a simple battery; however this work used the model Arduino UNO that is more adequate for experiments in laboratory due to its easy programming, high availability on the market at a low price.

The microcontroller detects the laser ray interruption and sends information to a personal computer thorough serial communication based on a USB hardware connection. Figure 3 shows the software layout, which runs in the personal computer to control the system. It shows in real time the counted number of drapes, the interval from the last counted drop, the drops rate per second, the drops frequency, the drop rate graphic and the file name to save the data.

Figure 3. The main system software for drip irrigation monitoring and analysis



In this work, the counting system was tested with a fan, whose blades continuous movement interrupted the laser ray, simulating physically the dripping. In tests producers, the signal from the photodetector was sent to the microcontrollers that counted the drops number and it also simultaneously sent to a digital oscilloscope model Tektronix line TDS200, which computed frequency with scientific accuracy. For a fan frequency of 254Hz measured by the oscilloscope, the drop counter developed in this work indicated 253.63Hz, with standard deviation of 0.88Hz and coefficient of variation of 0.35%, which proves its efficiency.

Table 1 shows the results of an experiment where the water tank was filled with 100ml of water and the number of drops was counted. Besides the relation between volume and drops number was computed to express the mean drop volume, which can be useful in drip irrigation lines where a specific drip emitter can be continually monitored to verify possible dripping variations, which can be associated with clogging processes.

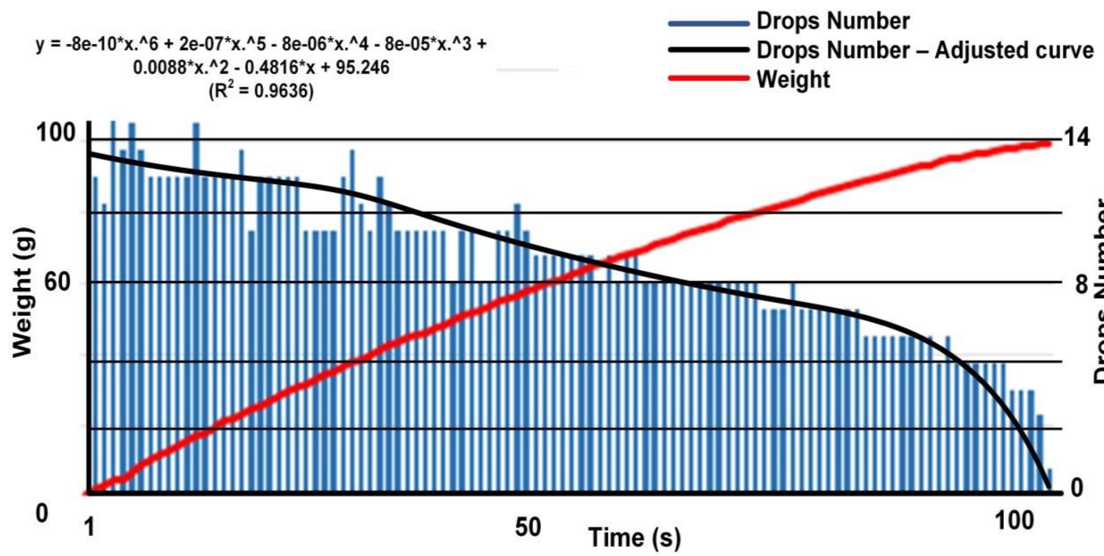
Table 1. Statistical analysis with the dripping of 100 ml of water.

	Number of drops	**ml/drop**
Mean	968.63	0.1036
Standard deviation	60.62	0.01
CV (%)	6.26	6.37

This work also used a load cell model TL-10 to measure the water volume weight accumulated in the bucket with a measurement limit of 25Kg and was also connected to the Arduino board through an interface module model HX711 that is a Load Cell Amplifier and allows a simple operation to measure weight and can be calibrated with simple procedures. It has a powerful analog-to-digital converter with 24 bits that can detect input voltage variations of at about $60*10^{-9}$V. The HX711 returned an dimensionless number proportional of the measured weighing and this number was read by an Arduino board using a free software library called “HX711.h” that performs the HX711 control and sends the final measurement number directly to a personal computer, where a simple software o data reception received and recorded the information. In this work, the weighing system accuracy verification was based on the analysis of several measurements of a known weight of 2,058Kg. The proportional number recorded for this weight presented a mean value of 369820, with a standard deviation of 3.81 and coefficient of variation of 0.001%, which proves the system efficiency for weighing measurements.

This work also includes an experiment that counts the number drops that fall from a tank and are caught in a bucket whose weight is simultaneously measured, allowing accurate uniformity verification. Figure 4 shows this experiment result, where the drops number decreases over time, which was previously expected due to the absence of system pressurization. The counted drops variation over time can be better represented when it is fitted with a polynomial adjust that is shown with the continuous blue line in figure 4 and has an R-squared of 0.9636, which proves a satisfactory system response.

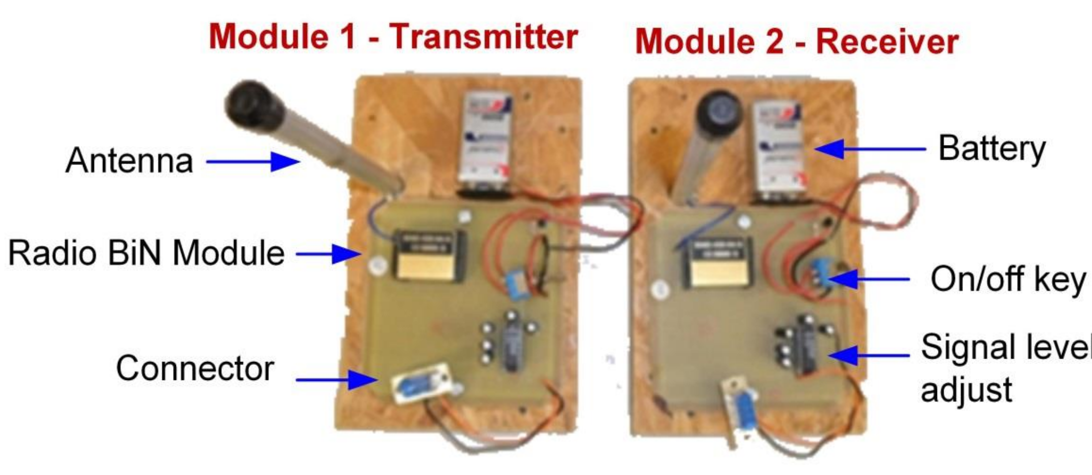
Figure 4. Dripping and weighing variation over time



The experiment above was developed inside a laboratory with satisfactory results and it is important for scientific essays of irrigation system evaluation and characterization. However, its field deployment along a drip irrigation line requires the use of several computers on field, which can be a critical operation due to the computers physical size, high power consumption and risk of computers damage. Therefore, this work also proposes the feasibility of the system above integration with radio telemetry systems, where a measurement point along the drip line sends its data to a remote computer through radio waves.

Figure 5 shows the telemetry hardware system designed in this work, which is based on a radio module model BiM-433 of the Radiometrix manufacturer.

Figure 5. Radio modules for telemetry and networking with the BiM-433



The module radio consumption for the data transmission operation is 17,5mA, which means that a battery type AA (length of 5cm and diameter of 1.45cm) with capacity of 2500mAh could supply this hardware for six days, while a motorcycle battery with 7Ah could provide power for seventeen days. Note that, it is for continuous daily transmission with batteries that can be rechargeable and besides the radio transmitter can also be powered with solar panels. In fact, for a system that only records data and transmit then in intervals of one hour, the expected battery life is about two months for batteries with capacity of 2500mAh. The system reliability relative to data transmission errors also was verified. Table 2 shows the computed errors for the transmission of 1000 bytes at a length of 120 meters between the transmitter and the receiver.

Table 2. Statistical analysis of data error transmission.

	Radio Transmission Baud Rate	
Statistical parameter	**14400 bps**	**9600 bps**
Mean of correct bytes transmitted	995.10	1000
Standard deviation	2.30	0
Coefficient of variation	0.23%	0

The presented radio transmission with low errors rate and satisfactory battery life operation proves the telemetry efficiency for field application. The BIM module works with a fixed frequency of 433MHz for data transmission and it means that only one transmitter can operate at a specific, otherwise the signal from one transmitter will interfere with the signal from others and the information received will be totally wrong. However, this problem can be solved through a software technique called Time Division Access (TDA) where the transmission of several modules occurs sequentially, one after the other, and at a specific time only one transmitter operates, which impedes the occurrence signals interference.

6 CONCLUSION

This work has shown that technological trends including microcontrollers, LabVIEW and wireless sensors network composes an efficient scenario for the development of electronic system focused on drip emitters monitoring. It counted the number for drops per time unit from a emitter with a satisfactory efficiency, which statistical coefficient of variation of 6.26% and it also allowed the data transmission with radio system the range from 100 meters to one kilometer.

7 ACKNOWLEDGEMENTS

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