

Design and development of an electronic card of radio control for adapt it to a system of irrigation conventional with activation of radio frequency

Diseño y desarrollo de una tarjeta de radiocontrol para adaptarlo a un sistema de riego convencional con activación de radiofrecuencia

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Abstract

A radio control card was designed and developed to adapt to a conventional irrigation system with radio frequency activation for the State of Puebla, Mexico. In the design of the double-layer printed circuit board, the modules of decode of dual tone multi frequency and two of record and playing of audio were employed. The control functions were carried out with a microcontroller, the power stage was adapted using two triodes of alternating current to activate two contactors, in addition, three relays were placed; the first has the function of regulating the temperature, the second activates the radio transmitter and the third turns on the lighting in the cabinet, temperature control is carried out through a sensor. An electronic radio control card was obtained with the ability to connect to a radio transmitter to activate and deactivate loads of high demand for electrical energy at a distance of 2 linear km, allowing to reduce the times in the irrigation system and to confirm the audio messages on the mobile radio, the card is low cost compared to the market and its operation is simple.

Resumen

Se diseñó y se desarrolló una tarjeta de radiocontrol para adaptarse a un sistema de riego convencional con activación de radiofrecuencia para el Estado de Puebla, México. En el diseño de la tarjeta de circuito impreso de doble capa, se emplearon los módulos de decodificación de doble tono multi-frecuencia y dos de grabación y reproducción de audio. Las funciones de control se llevaron a cabo con un microcontrolador, se adaptó la etapa de potencia utilizando dos triodos de corriente alterna para activar dos contactores, además se colocaron tres relevadores; el primero tiene la función de regular la temperatura, el segundo activa al radiotransmisor y el tercero enciende la iluminación en el gabinete, el control de temperatura se lleva a cabo a través de un sensor. Se obtuvo una tarjeta electrónica de radiocontrol con la capacidad de conectarse a un radiotransmisor para activar y desactivar cargas de alta demanda de energía eléctrica a una distancia de 2 Km lineales, permitiendo reducir los tiempos en el sistema de riego y confirmar los mensajes de audio en el radio móvil, la tarjeta es de bajo costo en comparación al mercado y su operación es simple.

Radio frequency, Irrigation system, Radio control

Radiofrecuencia, Sistema de riego, Radiocontrol

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Introduction

Technological advancement has allowed the economic development of countries since an advance in the development of science began, but today more than ever the global situation of confinements due to severe acute respiratory syndrome (SARS CoV2 for its acronym in English), and the disease it causes is called COVID-19. It is essential not to neglect the crops. This is why the use and implementation of electronic communication and radio frequency cards can control sprinkler irrigation systems remotely, to have control without the user being present and in this way there is no shortage in crop production. agricultural.

The municipality of Libres is located in the north-central part of the State of Puebla, an approximate distance from the City of Puebla of 165 km, the approximate number of inhabitants is 11,283. The name of the municipality comes from the Nahuatl roots that signify "big land". It has an area of 275.48 square km. Topographically they are perfectly defined in two zones; the east of the municipality is a plain, and the west presents a quite mountainous relief.

The municipality does not have important surface currents; however, a large number of streams originate in the mountain complexes. The municipality has a temperate semi-dry climate with rains in summer and little throughout the year. Its main economic activity is commerce and agriculture (H. Ayuntamiento de Libres, 2014).

In the State of Puebla, there are two systems of agricultural production; 1) the irrigation infrastructure with filtering galleries, irrigation channels, ditches or ditches to take advantage of the rainwater from the ravines, springs and other minor works, and 2) the temporary mountain range is production from the orchards where they cultivate the following seeds: Beans, wheat, capulín (seed), broad bean, corn, pochote and pine nut. The condiments that are generally harvested in the State of Puebla are: Epazote, peppermint, holy leaf, parsley, thyme, avocado leaf, bay leaf and oregano.

The production of fruits are the following: Chirimilla, guaje, apricot, sugar apple, polochocos, capulín, mamey sapote, mango, guava, white sapote, apple, pomegranate, tejocote, chico sapote, pear, quince, banana, chayote, black sapote, Granadilla, pitaya, fig, cuajilote, xoconostle, pitahaya, avocado, tamarind, tomato, yellow sapote, tilapo, guaje, peach, coyol, halaches, chupandilla, jiotilla, mesquite (pod), pitaya, guaje and nopal-tuna (Granados Sánchez, 2004). In other regions such as the northern highlands of Puebla, coffee plantations are the main harvest, these plantations incorporate various trees for shade. Producers have applied novel techniques such as the development of organic production systems, making them sites with potential for the development of new crops that can contribute to the economy of the region (Martínez et al., 2007). The State of Puebla is characterized by the cultivation of chili peppers due to its cultural-gastronomic tradition such as: The 'Poblano chile' or 'Mulato' for being a basic ingredient of traditional dishes such as "mole poblano" and "chiles en nogada" (Rodríguez et al., 2007). It is also characterized by being a region of fertile soil for the harvest of corn on the cob, the genetic diversity in Latin America is 50 races and in Mexico there are only 12 of them that are equivalent to 23% and 77% of diversity is present in the rest of America (Gil-Muñoz et al., 2004).

Irrigation provides crops with essential water for their growth and development. The implementation in irrigation systems through automatic control programming ensures optimal water supply (Espinosa et al., 2011).

Irrigation is defined as the artificial application of water to the ground in order to supply plant species with the moisture necessary for their development (Orson W. Israelsen, 1952). The forms of irrigation are Irrigation by laying or by flooding, Irrigation by platforms or borders, Irrigation by Furrows, Irrigation by sprinkling, Drip irrigation and Irrigation by Microjet (Quispe Tapara, 2018). At the global level, agricultural food production activity requires; among many aspects, the supply of basic resources such as water and constant electricity.

The growth of the harvest will depend on the obtaining and distribution of resources, in some developing countries the supply of electrical energy to the cultivation areas is not profitable for the electricity supply companies, for these cases, technified irrigation can be implemented where diesel-based electric power generators are used, or some renewable energy such as wind or photovoltaic energy (Moreno Flor García, & col, 2013). Currently, electronic circuits, microcontrollers and development cards have been used to incorporate them into technified irrigation systems. In addition to using sensors that are a type of transducer that are responsible for transforming an analog electrical signal at the input, they generally convert physical variables to an electrical signal at the output that can be voltage or current, their purpose is to obtain the parameters in real time of measurements, by using sensors capable of measuring (reacting) to pH, soil moisture sensors, temperature sensors, solar radiation sensors and anemometers as variables of interest. Once the signal has been acquired through the sensors, the actuators are devices that transform an electrical signal at the input into another type of signal or amplitude (electrical, pneumatic, hydraulic, etc.) capable of modifying or altering the conditions of the crop.

The actuators receive the control order through the microcontroller and gives a necessary output (Cruz J., 2009). Systems have been developed with the implementation of remote activation, as in the region of Murcia a Spanish community, it is characterized by being dry and arid, it makes the development of efficient agriculture complicated, due to this problem they have implemented data acquisition and control systems through Modbus communication using ArduPLC for measurement and control, is a device that comes from the family of Arduino development boards that foresees its implementation in agricultural technology systems in the future, using "internet" as a means of communication so that the user has control of the wireless transmission in real time of the remote system, using the LabView program as a graphic interface, so that the end user can use it intuitively (Belmonte Martínez, 2020).

The development boards mainly Nanoarduino, Arduino, Arduino Mega, Galileo Intel and Launchpad TI, have been incorporated in the control and automation systems as well as in the process for the treatment of seeds that the farmers carry out, for example in the maceration and germination in the treatment of barley, to avoid loss of seeds (Herrera Jiménez *et al.*, 2020).

Water is the fundamental element for the development of agricultural activity, agriculture consumes more than 70 percent of the water available at the level. In Mexico 77% is used, with 6.3 million ha. under irrigation with global efficiencies less than 50%. Irrigation is the best option for food production Despite its enormous importance, poor distribution and contamination make this resource more scarce and expensive every day (Servín Palestina, 2017).

In this work an electronic radio frequency control card is presented as a prototype to integrate it into a sprinkler irrigation system using a microcontroller to operate it by radio control using a radio station that allows remote devices to be activated such as: the electric pump, displacement motor linear, lamps, fan and contactors. Its placement for the start-up located in the municipality of the city of Libres in the State of Puebla, to carry out the cultivation of potatoes, broccoli, radishes and carrots.

Hypothesis

The severe acute respiratory syndrome has generated a new way of human interaction. If you have an electronic radio control card that adapts to a conventional irrigation system with radio frequency activation that allows remote on / off, then there will be no need for staff to move, avoiding contact with other people to the place operation, for activating the actuators connected to the pumping system that allows the passage of the water flow.

Objectives

Develop a radio control card to adapt it to a conventional irrigation system with radio frequency activation, efficiently using the start-up of a sprinkler irrigation system, activated by a radio station with a range of 2 km, taking advantage of the use correct electricity and natural resource such as water, for the benefit of the environment, and avoiding contact with other people during the transfer in this syndicate confinement generated by SARS CoV2.

Methodology

In this work for the development of the electronic card, three modules were integrated into the system, one of them is a DTMF decoder and two are for audio recording and reproduction that allow two-way Half Duplex communication and are capable of activating / deactivating connected peripherals. to the ATMEGA328P-PU microcontroller through remote commands from a Motorola EP450 mobile radio, it also sends audible on / off alarms indicating the status of the system. A Motorola EM200 brand radio station was attached, the model LAM50QNC9AA1AN specifies the frequency range of 403-440MHz with a power level of 25W, UHF, 4 channels with the ability to program burst sending adapted to an RF connection and Mini UHF, there are two models with UHF ranges of 438-470 MHz and 465-495MHz, in addition a Motorola EP450 brand mobile radio was used with a frequency range: 438-470 MHz and consumes 4W with 64 channels, in addition It has a maximum range of 5 km, using two Brand contactors: Siemens model 3RH1122-1AK60 with four internal relays and a 10A coil; 2-NO 2-NC, 120 / 110V 60 / 50Hz.

The DTMF technique represents 16 alphanumeric characters of the phone (0-9, AD, *, #), see Table 1. The signal generated by the DTMF encoder is the algebraic sum, in real time, of the amplitudes of two sinusoidal waveforms of different frequencies as represented in Equation (1).

$$x(t) = A \sin(\omega_L t) + B \sin(\omega_H t + \varphi) \quad (1)$$

where ω_L and ω_H correspond to the low and high frequency ($\omega = 2\pi f$), A and B are the amplitude of the signals and φ is the initial phase shift (Artal et al., n.d.).

| Frequency | 1209Hz | 1336Hz | 1477Hz | 1633Hz |
|-----------|--------|--------|--------|--------|
| 697Hz | 1 | 2 | 3 | A |
| 770 Hz | 4 | 5 | 6 | B |
| 852 Hz | 7 | 8 | 9 | C |
| 941 Hz | * | 0 | # | D |

Table 1. Set of frequencies applied by DTMF.

Figure 1 shows the schematic circuit of the electronic card used for the sprinkler irrigation system, in this image the different connections of the peripheral devices that are coupled to the microcontroller that allow remote operation can be observed.

Power activation devices are had; relays and TRIACs. The ISD1820 audio recording and playback modules, coupled to an LM386 audio amplifier that controls the gain of the signal to be transmitted to the radio station so that the audio signal is not saturated, in addition to the MT8870 DTMF decoding module, finally , the DS18B20 sensor for sensing the system temperature.

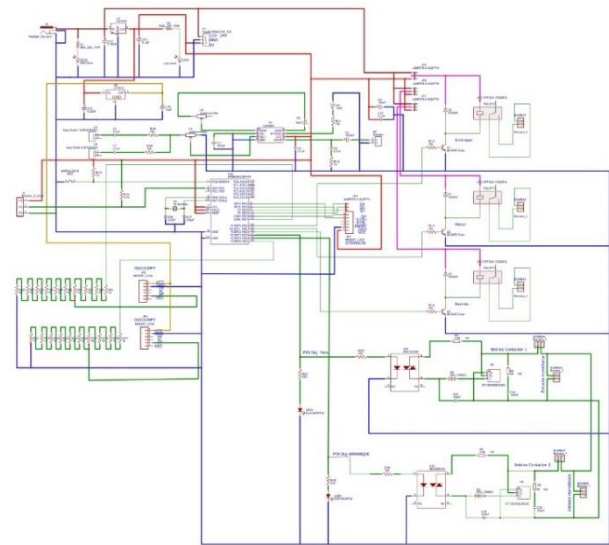


Figure 1 Schematic circuit corresponding to the electronic board

The connections in the prototype of the schematic circuit designed for assembly using a protoboard as shown in Figure 2, allows to visualize and detect errors in the connections and, to join each section of the circuit to be able to have the total system working.

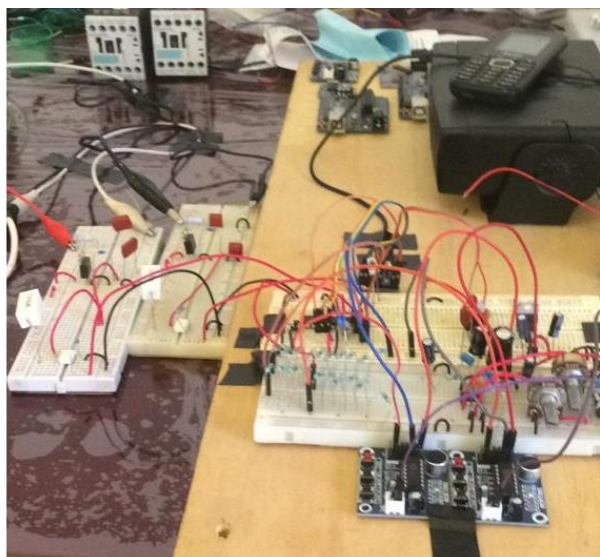


Figure 2 Mounting of electronic components and modules on the system breadboard

The PCB (for its acronym in English Printed Circuit Board) (E-Alfredo, & col., 2019) designed double layer corresponding to the electronic card used in the sprinkler irrigation system in Figure 3, a microcontroller is shown as the main programmable control device, which waits for the output of the DTMF decoder to start the different routines depending on the byte of characters sent by the EP450 mobile radio.

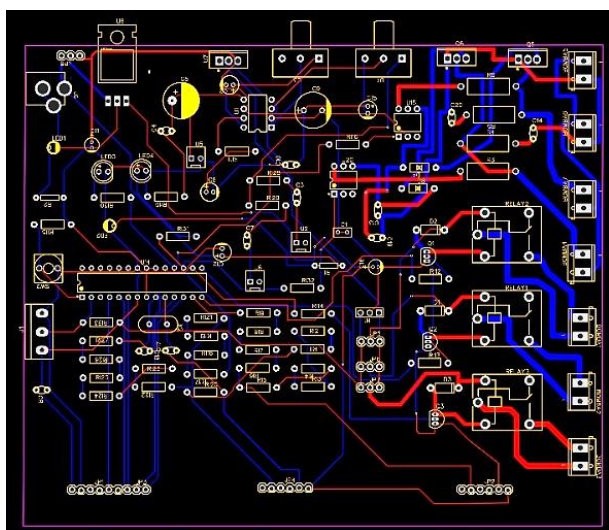


Figure 3 Design of the PCB prototype corresponding to the electronic circuit board for the irrigation system
Source: (Part, 2018).

The design of the electronic card in its first version for the sprinkler irrigation system shown in Figure 4 is connected to the Motorola radio station, where you can see the power devices connected to activate the on / off operation of high voltage loads, that is, the 10A SIEMENS brand contactors to operate the pump that acts as the main pumping device, the contactors being connected as a self-interlocking system, this allows that when the contactor is instantly activated, the entire high power system.



Figure 4 Experimental setup using the electronic card designed for the sprinkler irrigation system

The electronic card finished with the electronic elements and the DTMF and audio recording and reproduction modules that are coupled to the radio station to observe the operation as shown in Figure 5.



Figure 5 Modules incorporated into the electronic card connected to the radio station for transmission with Motorola EP450 equipment

Program for the control of the irrigation system in the ATMEGA328P-PU microcontroller, the declaration of the character arrangements assigned for the password and for the data received in the radio we use the following instructions (Arduino_Genuino, 2017):


```

        {
            digitalWrite(8, HIGH);
            delay(10000);
            digitalWrite(8, LOW);
        }
        else if(temperatura < 25)
        {
            digitalWrite(8, LOW);
        }
    }
    clearData();
}
toneLoc = false;
}
}
void clearData(){
    while(data_count != 0){
        Data[data_count--] = 0;
    }
    return;
}
void newDTMF(){
    toneLoc = true;
}
char dtmf_decode(byte recv_data){
    switch(recv_data){
        case 1: return '1';
        case 2: return '2';
        case 3: return '3';
        case 4: return '4';
        case 5: return '5';
        case 6: return '6';
        case 7: return '7';
        case 8: return '8';
        case 9: return '9';
        case 10: return '0';
        case 11: return '*';
        case 12: return '#';
        case 13: return 'A';
        case 14: return 'B';
        case 15: return 'C';
        case 0: return 'D';
        default : return '?';
    }
}
}

```

Results

The development of the electronic system has the ability to control and measure the operation of a sprinkler irrigation system, continuous use operation tests were carried out lasting 56 hours a week, with a transmission range between 0.1 and 2 linear kilometers. maintaining control of the system without any interference, ensuring the proper operation of the contactors, which allow the rational use of water and electrical energy, a fundamental part so that there is no waste, being a strategic point for crop production, due to Since a percentage greater than 50% is assigned to the consumption of water used in the irrigation of crops, the use of technology in this region is of great importance, since due to the confinement during the next months production will be reduced food.

Therefore, it is of great importance to use these electronic cards for remote irrigation systems without affecting production in the agricultural sector that influences the region's economy.

The secondary section of the pipe where pressurized water is released through the sprinklers to generate artificial rain with the ability to cover the surface of the irrigation land as shown in Figure 6, through the electronic card that controls the radio control system can activate and deactivate artificial rain and in this way the amount of water supplied to the crop is administered.



Figure 6 Bypass of secondary piping to the sprinklers operated with the use of the electronic card

The sprinklers and their connection to the main pipeline are embedded in a concrete slab to supply the flow of water as seen in Figure 7, in addition to the electrical panel to obtain the electrical energy necessary to operate the actuators to move the sprinklers. across the surface of the farmland.



Figure 7 Structure of main pipe for water supply with control board

The stopcock that allows the water flow to be directed towards the sprinklers is shown in Figure 8 this turns on / off through the relays controlled by the microcontroller, selecting the surface that will be sprayed by the sprinklers.



Figure 8 Main pipe and stopcock

Conclusions

An electronic card was designed and developed to adapt it to a radio control system and have the ability to control a remote sprinkler irrigation system in the Municipality of Libres, Puebla, Mexico, in order to face the situation that is occurring in Mexico and in worldwide, confinement due to severe acute respiratory syndrome (SARS CoV2).

The electronic card was left working daily, 56 hours a week continuously showing the operator having control of the effective water supply for the crop and executing the control instructions that make the irrigation system work correctly. The transmission and sending of the passwords by DTMF to the microcontroller, performs a correct response to execute the control routines and obtaining an auditory response on the Motorola EP450 mobile radio. This radio control system can activate and deactivate more than 2 linear kilometers from the receiver without any problem for the main pump actuators to carry out the water supply. This electronic card, compared to some existing on the market, reduces its cost up to three times, allowing farmers to incorporate technified irrigation systems, reducing the consumption of water and electricity, resulting in an economic retribution in production.

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References

- Arduino_Genuino. (2017). *No Title*. 18 de Octubre de 2017. https://create.arduino.cc/projecthub/Arduino_Genuino/contribute-to-the-arduino-reference-af7c37.
- Artal, J. S., Caraballo, J., & Dufo, R. (n.d.). *Tecnología DTMF aplicada a la Identificación y Control de un pequeño Robot Móvil*.
- Belmonte Martínez, S. (2020). *Master Universitario Oficial en Automatización y Telecontrol Estudio de Prototipo de mejora hardware / software para Automatización de Lisímetro de Pesada (LP3)*.
- Cruz J. (2009). *Diseño de un sistema de riego por goteo controlado y automatizado para uva italia*. 1–89.

E-Alfredo, G.-G., Jiménez-quezada, D. K., & Genaro, E. (2019). *Desarrollo de un sistema electrónico con desplazamiento bidimensional para obtener el flujo lumínico en distintas fuentes de iluminación para conseguir sus curvas características* Development of an electronic system with two-dimensional displacement to obt. 3(9), 1–9.

Espinosa, O. L., Nolasco, A. Q., Bauer Mengelberg, J. R., Hebert Del Valle Paniagua, D., Palacios Vélez, E., & Marín, M. Á. (2011). Prototipo Para Automatizar Un Sistema De Riego Multicultivo* Prototype for Automating a Multicropping Irrigation System. *Revista Mexicana de Ciencias Agrícolas*, 2, 659–672.

Gil-Muñoz, A., López, P. A., Muñoz-Orozco, A., & López-Sánchez, H. (2004). Variedades criollas de maíz (*Zea mays* L.) en el estado de Puebla, México: diversidad y utilización. *Manejo de La Diversidad de Los Cultivos En Los*, 18.

Granados Sánchez, D. (2004). *Estudio integral del valle de Tehuacán-Cuicatlán: recursos genéticos de plantas.*--p. 97-109. En: Manejo de la diversidad de los cultivos en los agroecosistemas

H. Ayuntamiento de Libres. (2014). *LIBRES*. <http://www.inafed.gob.mx/work/enciclopedia/EMM21puebla/municipios/21094a.html>

Herrera Jiménez, A., Miranda Castillo, J. R., & Martínez Villa, F. (2020). *Automatización del proceso de maceración y germinación de la cebada para la elaboración de malta utilizada en la cerveza artesanal*.

Martínez, M. Á., Evangelista, V., Basurto, F., Mendoza, M., & Cruz-Rivas, A. (2007). Flora útil de los cafetales en la Sierra Norte de Puebla, México. *Revista Mexicana de Biodiversidad*, 78(1), 15–40.

Moreno Flor García, Juan Bedoya Fierro, G. A. L. M. (2013). Modelo a escala de un sistema de riego automatizado, alimentado con energía solar fotovoltaica: nueva perspectiva para el desarrollo agroindustrial colombiano. *Tecnura*, 17(2), 33–47. <https://doi.org/10.14483/22487638.7221>

Orson W. Israelsen, V. E. H. (1952). Principios y aplicaciones del riego. In *El Día médico* (Vol. 24, Issue 58, pp. 1525–1527).

Parte, G. B. (2018). *Normas Internacionales Basicas Para Diseño De*. 1–7.

Quispe Tapara, H. (2018). Diseño de un sistema de riego automatizado por aspersión para viveros de café utilizando la tecnología Arduino en la empresa Viveros Ortíz - Pasco; 2018. *Uladech*, 10(2), 1–15. https://www.uam.es/gruposinv/meva/publicaciones/jesus/capitulos_espanyol_jesus/2005_motivacion_para_el_aprendizaje_Perspectiva_alumnos.pdf%0Ahttps://www.researchgate.net/profile/Juan_Aparicio7/publication/253571379_Los_estudios_sobre_el_cambio_conceptual_

Rodríguez, J., Olvera, B. V. P., Muñoz, A. G., Corona, B. M., Manzo, F., & Liendo, L. S. (2007). Rescate in situ del chilipoblano en Puebla, México. *Revista Fitotecnia Mexicana*, 30(1), 25–32.

Servín Palestina, M., Tijerina Chávez, L., Medina García, G., Palacios Velez, O., & Flores Magdaleno, H. (2017). Sistema para programar y calendarizar el riego de los cultivos en tiempo real. *Revista Mexicana de Ciencias Agrícolas*, 8(2), 423. <https://doi.org/10.29312/remexca.v8i2.61>