

A Hydrogen detectors Wireless network for monitoring the gas ambient in a laboratory.

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Abstract. A system to monitor the hydrogen contents in the atmosphere present in the various sections of a crystal growth laboratory has been built. When hydrogen is used in the processes carried out in a laboratory it is important to monitor its content because the oxygen-hydrogen mixture is highly flammable and/or explosive. The system emits a warning when the Hydrogen concentration increases and if the concentration rises above 1 % in vol. it shuts down automatically any process that is using hydrogen. The design and performance of the system is reported here.

1. Introduction.

Hydrogen is necessary in many industrial and laboratory processes but there is the problem that when its concentration in the atmosphere is higher than normal the mixture is highly flammable and if its concentration reaches 4 % in vol. the mixture explodes if its temperature reaches 80 °C., the explosion can be triggered by a spark produced by a short circuit or the opening of a switch in an electric circuit [1, 2, 3, 4, 5].

It is then highly desirable to have a system to permanently monitor the hydrogen concentration in the ambient atmosphere if a small rise in the concentration is detected it is a sign that a Hydrogen is leaking somewhere in the process and if it is detected at an early stage the leakage can be found and stopped before the Hydrogen concentrations reaches dangerous values. Also, if somehow the Hydrogen concentration rises above a certain threshold an automatic shut-off of any hydrogen flow or electric circuit could prevent an explosion [1, 2, 3, 4, 5].

2. Design of the detectors wireless network.

A block diagram of the network is shown in Fig. 1 it consists of three boards containing a Hydrogen sensor, the signal of the sensor is connected directly to one of the internal ADC converters of a PIC16F877A microcontroller [6]. Depending on the value of the signal the microcontroller sends one of three different commands and an identification signal through a radiofrequency transmitter. There are two reception boards one located outside the laboratory and the other, inside the laboratory, is connected to a PC that controls the experiment where hydrogen is being used.



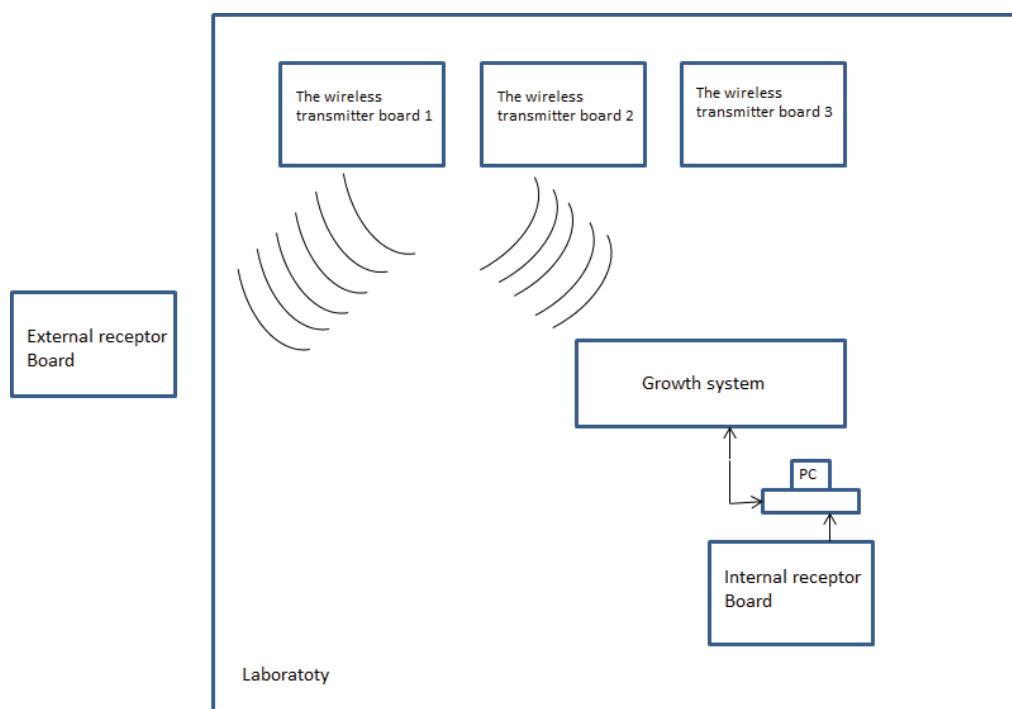


Figure 1. A block diagram of the detectors wireless network.

The external reception board uses the transmitted signals to identify the sender and to perform three different tasks depending on the command received. One command indicates that the hydrogen concentration is normal and constant, in this case there is a green LED lighted on in the reception board, other command indicates that the hydrogen concentration is above normal but below a certain limit the receptor module then emits a continuous audible and a low frequency intermittent visual yellow warning and on the third command, issued when the Hydrogen level reaches a dangerous limit, the receptor board emits an audible alarm and a high frequency intermittent red LED light signal.

The internal receptor board communicates with a PC and is used only to shut off the process when the hydrogen concentration exceeds certain limit corresponding to the third command as above.

Each detector board emits audible and visible signals according to the command it is transmitting.

Fig. 2 shows a block diagram of each Hydrogen detector board. It contains the hydrogen sensor a signal conditioning module, the microcontroller, the RF transmitter and audible and visual Indicators, each part will be described in detail below.

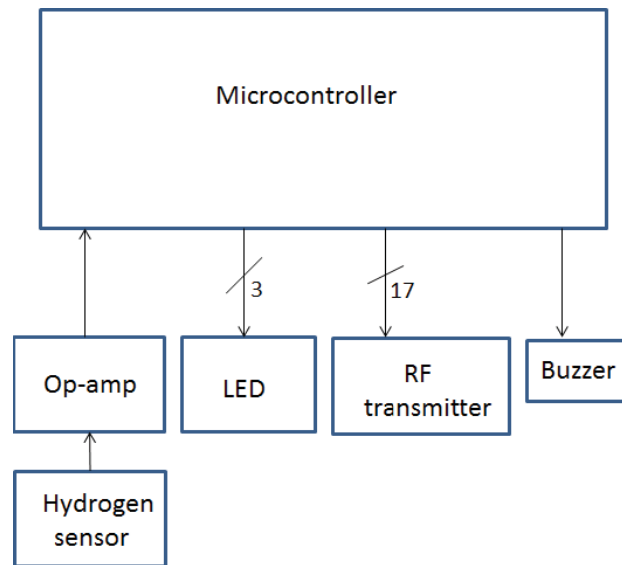


Figure 2. Block diagram of the wireless detector.

The external reception board is shown in the block diagram of Fig. 3. The internal reception board is not shown it consists simply of a RF receiver and a microcontroller that send a signal to a DAQ board in the PC, when this signal is detected the PC shuts off the process.

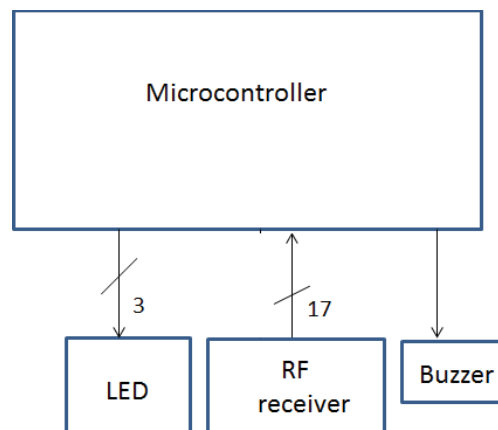


Figure 3. Block diagram of the wireless receiver.

2.1. The Hydrogen sensor

The hydrogen concentration is measured with a sensor of the company Synkera, model H2-PN-701 it can measure Hydrogen concentrations in the range 10-1000 ppm. The internal resistance of the sensor changes according to the hydrogen concentration. The characteristics of the sensor [3] are shown in Fig. 4.

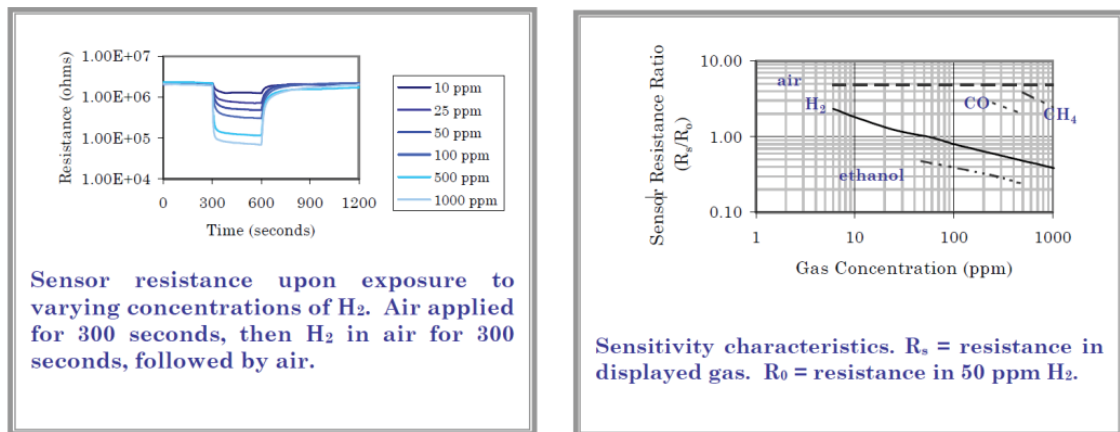


Figure 4. Sensor response in the presence of hydrogen.

The bias circuit of the sensor is shown in Fig. 5 (8). It utilizes a heating voltage (V_H) of 5.4 V. The voltage supply to the divider (V_C) is 5.0 V. The hydrogen concentration in contact with the sensor can be estimated from the internal resistance of the sensor (R_S) and Fig. 4b above. The value of R_S can be deduced from V_{Out} [3].

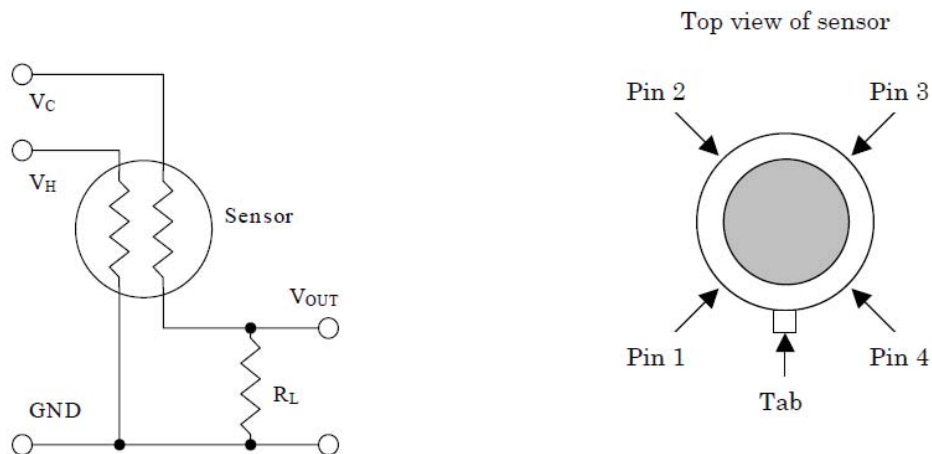


Figure 5. Basic measurement circuit is connected to pin 1 to 3 and heating voltage to pins 2-4 to the supply voltage.

2.2. The wireless transmitter board

In our case there are three transmitter boards. The block diagram of the wireless transmitter board is shown in Fig. 2. The board is designed around a PIC16F877A microcontroller [6]. It measures the output of the sensor (V_{Out}) using one of its ADC converters, depending on its value it codifies the data that will be send by the RF transmitter and sets the corresponding state of the LEDs and buzzer. The signal was transmitted using a TWS-434 amplitude modulated (AM) radiofrequency transmitter working at 433.92 MHz with a maximum transmission rate of 8 Kbps [8, 9]. The corresponding circuit is shown in Fig. 6.

The data transmitted consist of a sequence of 17 bits with the following structure:

- A starting bit

- 8 address bit used to verify that the signal comes from a transmitter that belongs to the system.
- 8 data bits, the first 4 bits are the data bits and the other bits identify the transmitter board sending the signal.

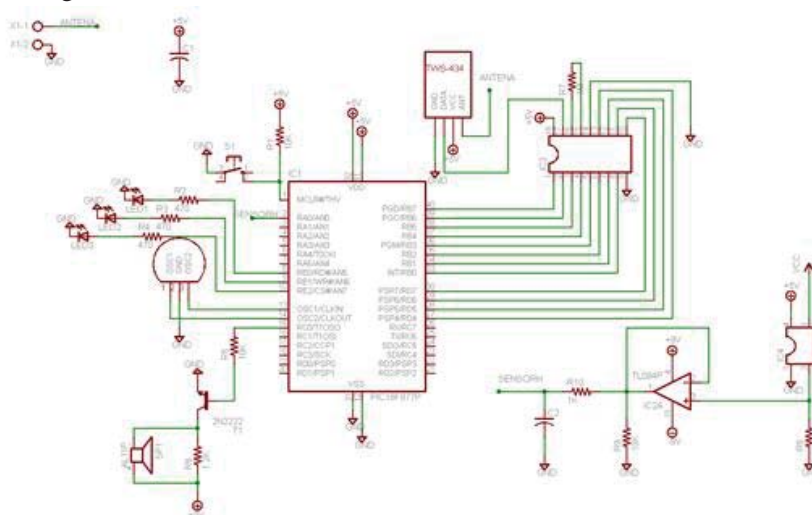


Figure 6. Transmitter circuit board.

Between each 17 bits transmission there is a time period of the same length as the 17 bits where no data is transmitted.

2.3. The wireless receptor Board

This board was designed using a PIC16F877A microcontroller [3] and a RWS-434 RF receptor module its block diagram is shown in Fig. 3. The data received is fed to the microcontroller which decodes the information to identify the transmitter board and to indicate the hydrogen level in the area where that transmitter board is located [10, 11]. The corresponding circuit is shown in Fig. 7.

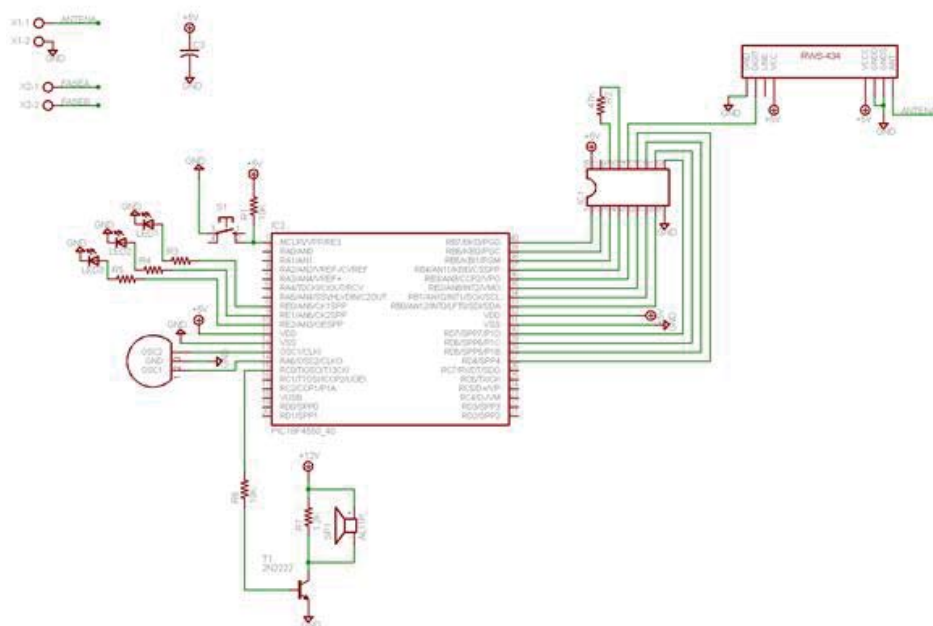


Figure 7. Receiver circuit board.

2.3.4 Network operation.

Since there are three transmitter boards and only one reception board it is necessary to synchronize the transmitters because if any two of them were transmitting at the same time they would interfere and the receptor could not decode the signal transmitted. So there is a transmission sequence as shown in Fig. 8. The transmission of each board lasts 5 s and is followed by a 2 s dead period.

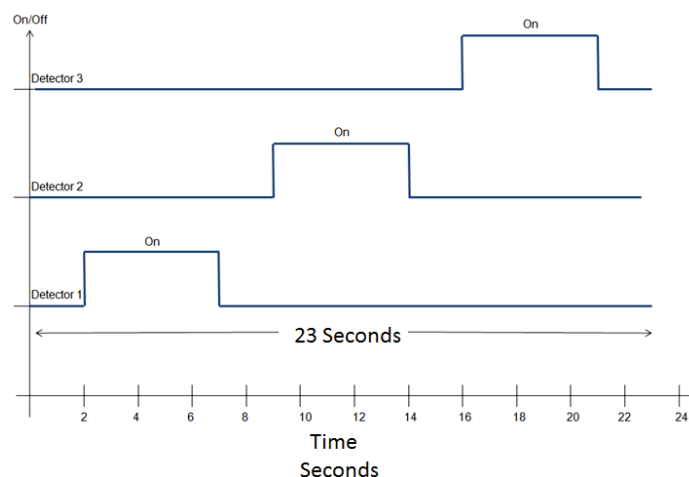


Figure 8. Diagram of wireless network operation.

3. Results

The system has been tested to check for the signal variation when there is no extra Hydrogen in the atmosphere it was found that with a Load Resistance (RL) of 1.00 K Ω the signal remains between 50 and 70 mV. Leakages of Hydrogen were simulated by blowing the detector board from below at several distances with a 0.7 l/min flow of a gas mixture containing Hydrogen (5 % H₂ -95 % Ar). The time response depends mainly on the arrival time of the Hydrogen to the sensor. And the system gives either an alarm or warning signals depending on the distance of the blowing nozzle and on how long the flow lasts.

4. Conclusions

A wireless system for Hydrogen detection has been developed. It can detect dangerous concentrations of Hydrogen in different locations and send a warning signal to a receptor unit that can be located up to 50 m apart from the transmitter boards. Other receptor boards can communicate with a PC to shut down the hydrogen flow if necessary.

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