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THE RADIOMEASURING HUMIDITY SENSOR

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Abstract

Developed the radiomeasuring air relative humidity sensor with the frequency output signal, where as the primary sensor used Honeywell company sensor. The dependences of transformation function and equation of sensitivity of the radiomeasuring air relative humidity sensor are obtained. The equation of the sensitivity shows that with the relative humidity changes from 0 %RH to 100 %RH the sensitivity varies from 550 Hz/%RH to 350 Hz/%RH. The discrepancy between the theoretical and experimental results is 5%.

Keywords: humidity, sensor, negative resistance, frequency, transformation function.

Анотація

Розроблено радіовимірювальний сенсор відносної вологості повітря з частотним вихідним сигналом, де в якості первинного сенсора використано датчик фірми Honeywell. Отримано залежності функції перетворення та рівняння чутливості радіовимірювального сенсора відносної вологості повітря. Рівняння чутливості показує, що при зміні відносної вологості від 0 % до 100 % чутливість змінюється від 550 Гц/% до 350 Гц/%. Розбіжність між теоретичними та експериментальними результатами становить 5%.

Ключові слова: вологість, сенсор, від'ємний опір, частота, функція перетворення.

Introduction

Measuring equipment is an integral part of our life in today's world. Measuring various physical quantities is an urgent problem which not one scientific school has been working on for decades. The number of physical quantities that can be measured increases every year due to the rapid development of scientific and technological progress, information processing tools [1] and technologies that allow to develop new sensors of physical quantities. But it is not necessary to create a new class of physical quantity sensors. It is also important to improve existing sensors. These basic characteristics include measurement accuracy, sensitivity and threshold of sensitivity sensor. This paper focuses on the sensors to measure humidity.

The humidity sensors are part of many measuring tools and measurement systems and help to monitor the quality of products. The tasks of monitoring and control of technological processes in various industries is impossible without the use of the relative humidity sensors.

Theoretical and experimental research

Theoretical studies have shown that using transistor structures with negative resistance significantly increases the sensitivity and the accuracy of the measuring signal, in this case the relative humidity [2, 3]. The block diagram of the radiomeasuring humidity sensor with the frequency output signal is shown in figure 1.

The device consists of two main parts: the radiomeasuring sensor unit and the information processing unit as seen from the block diagram.

The radiomeasuring humidity sensor consists of the primary and the secondary sensors. The primary sensor converts the relative humidity in the capacity. As the primary sensor Honeywell company sensor HCH-1000 is used, which has a sensitivity 0,6 pF/%RH. The transformation function of the primary sensor is displayed in figure 2.

The secondary sensor is developed on the basis of self-oscillator transistor structure with negative resistance. The primary sensor capacity changes the equivalent capacitance of the self-oscillator and causes an effective change in the output signal frequency of the self-oscillator.

The calculated values of the frequency via the data bus gets to the microprocessor which provides a graphical visualization of the relative humidity on the LCD display.

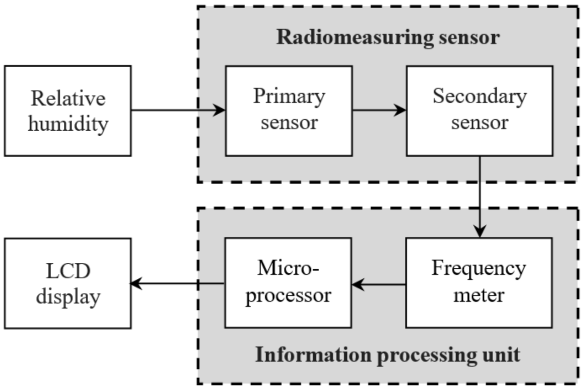

Fig. 1. The block diagram of the radiomeasuring humidity sensor with the frequency output signal

The calculated values of the frequency via the data bus gets to the microprocessor which provides a graphical visualization of the relative humidity on the LCD display.

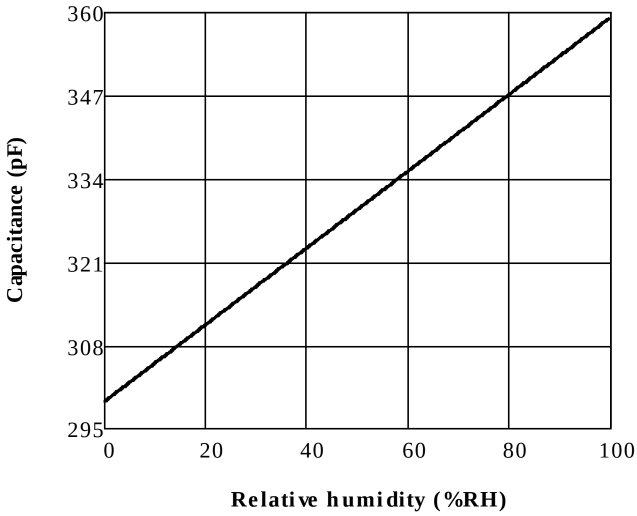

Fig. 2. The transformation function of the primary sensor

The electric circuit of the secondary sensor is shown in figure 3. The dynamic mathematical model of the radiomeasuring humidity sensor is developed and presented in scientific research [4]. It allows you to determine the voltage and current at any point of the circuit at a given time.

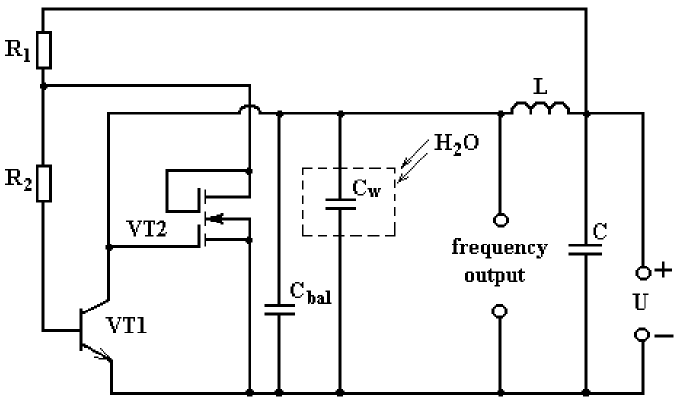

Fig. 3. The electric circuit of the secondary sensor

For experimental research in the secondary sensor circuit transistors BF240 and BF998 with supply voltage U = 1,25 V are used.

Knowing the output signal frequency *F* for different values of the humidity sensitive capacitance C_W the transformation functions of the secondary sensor was received.

The theoretical transformation functions of the secondary humidity sensor for different values of inductance are displayed in figure 4.

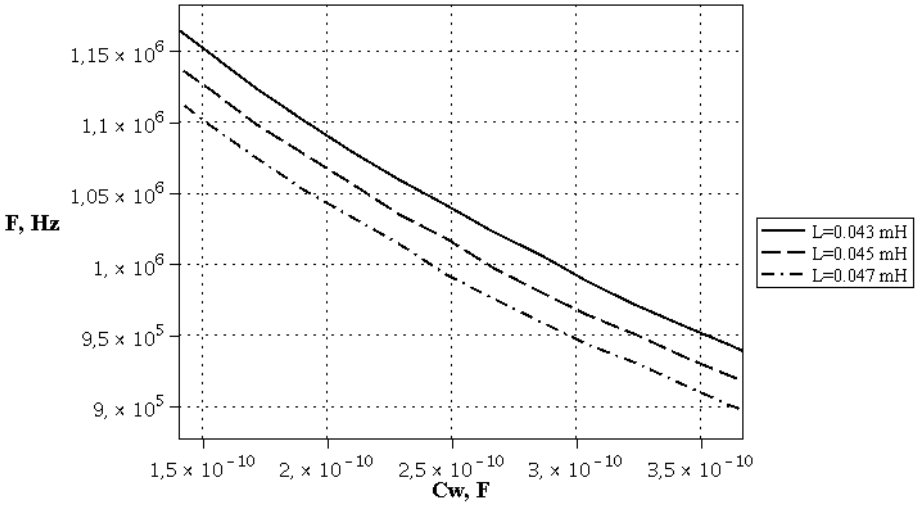

Fig. 4. The theoretical transformation functions of the secondary sensor

The transformation function of the radiomeasuring humidity sensor with the frequency output signal is described by the equation:

$$F = \frac{\sqrt{LC_cC_eC_i(W)\left(C_cC_e + C_cC_i(W) + C_eC_i(W)\right)}}{2\pi LC_cC_eC_i(W)}, \tag{1}$$

where C_c, C_e – capacity of the collector and emitter junction respectively;
$C_i(W) = C_w(W) + C_{bal}$.

On the basis of the equation (1) the transformation function graph of the radiomeasuring humidity sensor was obtained, which is shown in figure 5.

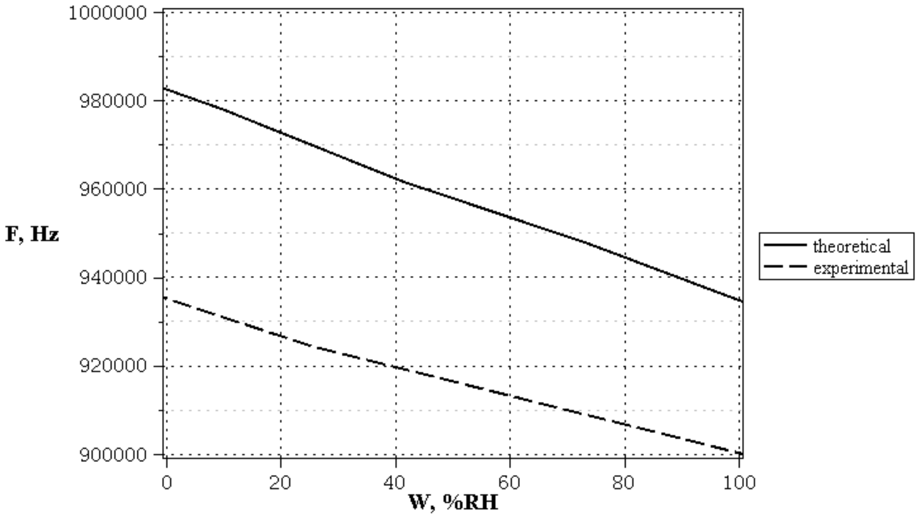

Fig. 5. The theoretical and experimental transformation functions of the radiomeasuring air humidity sensor

Figure 5 shows that with the humidity changes from 0 %RH to 100 %RH the frequency decreases from 936 kHz to 900 kHz. The discrepancy between the theoretical and experimental results is 5%.

The sensitivity of the radiomeasuring air relative humidity sensor, based on the expression (2), is determined:

$$S_W = \frac{LA_1\frac{\partial C_i(W)}{\partial W} + LC_eC_cC_i(W)\left(C_c + C_e\right)\frac{\partial C_i(W)}{\partial W}}{4\cdot\left(\pi LA_2C_cC_eC_i(W) - \frac{A_2\frac{\partial C_i(W)}{\partial W}}{2\pi LC_cC_eC_i^2(W)}\right)}, \tag{2}$$

where $A_1 = C_cC_e\left(C_cC_e + C_cC_i(W) + C_eC_i(W)\right)$; $A_2 = \sqrt{LC_cC_eC_i(W)\left(C_cC_e + C_cC_i(W) + C_eC_i(W)\right)}$.

The dependence of the sensitivity on the humidity changes is displayed in figure 6.

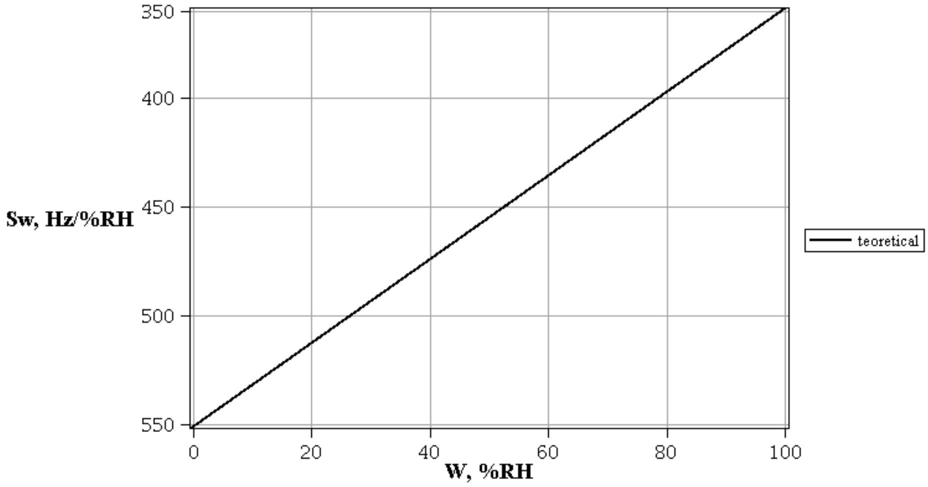

Fig. 6. The dependence of the sensitivity on the humidity changes

Figure 6 shows that with the humidity changes from 0 %RH to 100 %RH the sensitivity varies from 550 Hz/%RH to 350 Hz/%RH.

Conclusion

The possibility of creating the radiomeasuring air relative humidity sensor with the frequency output signal based on the transistor structure with negative resistance is showed. Based on the mathematical model of the radiomeasuring air relative humidity sensor the dependences of transformation function and equation of sensitivity are obtained. The sensitivity of the radiomeasuring air relative humidity sensor is 450 Hz/%RH on the average.

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