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MICROELECTRONIC FREQUENCY CONVERTER OF HUMIDITY

The paper considers the possibility of creation of microelectronic frequency converter of petroleum products humidity on the basis of transistor structure with negative resistance in combination with humidity sensitive condenser cylindrical structure. Experimental transfer function, of frequency converter of petroleum products humidity has been obtained.

Key words: *humidity, humidity converter, negative resistance, condenser cylindrical structure, petroleum products.*

Introduction

Humidity converters occupy specific place among various types of sensors in the sphere of measuring engineering. The problem of design and manufacturing of measuring devices is of paramount importance, especially in such branches as food industry, aircraft industry, space engineering, chemical, oil –gas industry, where the efficiency of operation greatly depends on the accuracy of humidity measurements. Control of oil humidity is necessary on the stages of its production, storage, transportation and processing [1]. The presence of humidity in petroleum products causes changes of their physical chemical parameters and reduces the term of their usage.

Theoretical studies have shown, that the usage of transistor structures with negative resistance and reactive properties of semiconductor devices considerably increase sensitivity and accuracy of measurement of the investigated signal, in our case, the humidity of petroleum products [2, 3].

The important problem is determination of voltage-current characteristic of frequency humidity-sensitive converter as the selection of operation point on this characteristic specifies selfexcitation and stability of converter autogenerator operation and determination of transfer function as well as sensitivity equation dependence.

Main part

Fig. 1 shows electric diagram of frequency converter of petroleum products humidity (FCPH), humidity sensitive element of which being condenser cylindrical structure (CCS) [4, 5]. FCPH consists of direct voltage sources U_1 and U_2 of the transistors VT1 and VT2, humidity sensitive condenser C_W, inductance coil L_1, limiting capacitor C_1 and resistors R_1 та R_2.

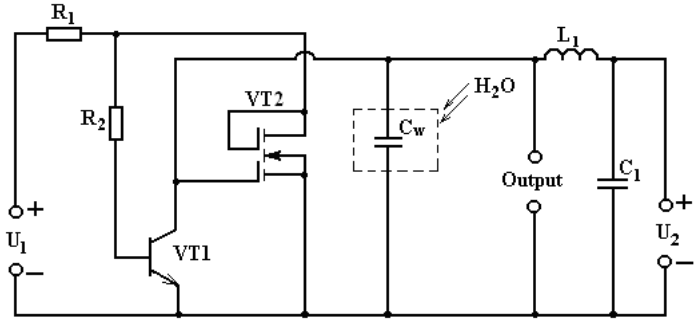


Fig. 1. Electric diagram of petroleum products humidity frequency converter

Unit for humidity determination operates in the following manner. At initial moment of time, the humidity does not influence CCS C_W. With the increase of supply voltage U_2 to the value, when negative resistance emerges at the electrodes of the emitter-the first gate of transistors VT1 and VT2, this negative resistance leads to generation of electric oscillations in the circuit. The circuit is

formed by parallel switching of the impedance with capacitance component on the electrodes of emitter-first gate of transistors VT1 and VT2 and inductance L_1. During the next impact of the humidity on CCS C_W the capacitance component of the impedance on the electrodes of emitter-first gate of transistors VT1 and VT2 changes, that causes efficient change of oscillatory circuit frequency.

By means of circuit engineering modeling in Orcad Family Release 16.0 environment, using the transistors BF240 and BF998 voltage-current characteristics (VCC) for humidity converter at different control voltages were obtained, they are shown in Fig. 2. These characteristics show the presence of the section with negative resistance, also, it can be seen, that if control voltage U_1 increases, the section of negative resistance increases too. If U_1=1,2 V the section of negative resistance U_2 is from 0,1 V to 0,5 V, if U_1=1,35 V – the section of negative resistance is from 0,15 V to 1,3 V, and if U_1=1,5 V the section of negative resistance is from 0,17 V to 1,55 V. Discrepancy of theoretical and experiment VCC is not greater than 3%.

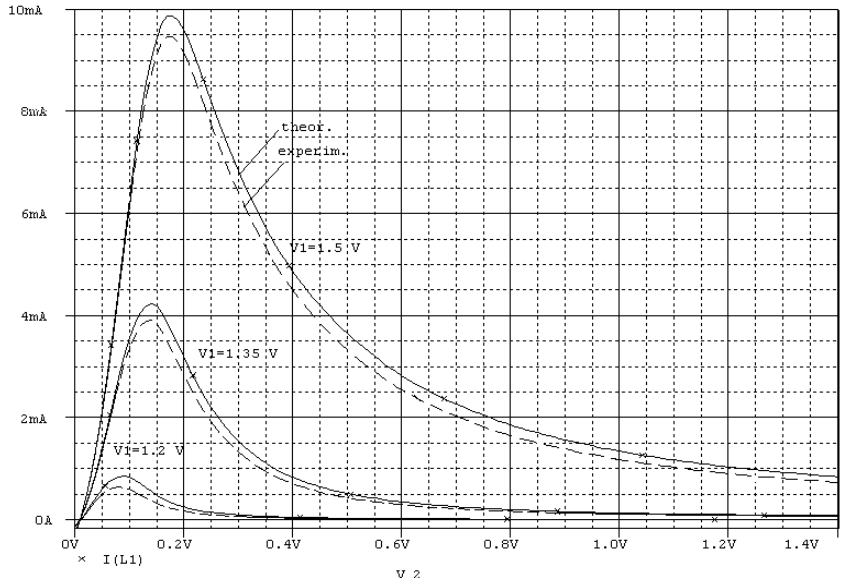
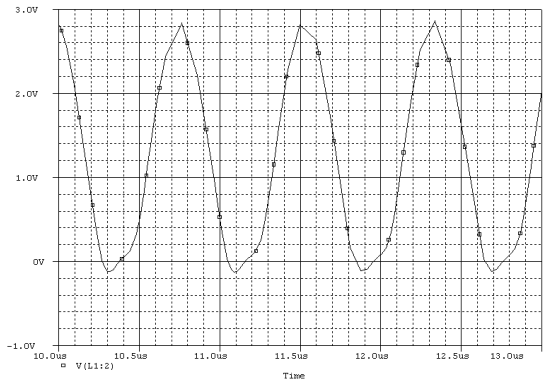


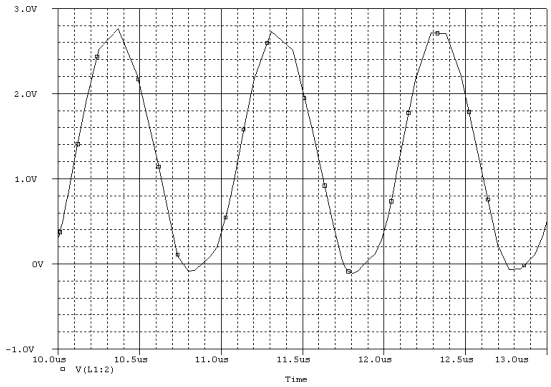
Fig. 2. VCC of frequency converter of humidity

In electric circuit of FCPH (Fig. 1) as a result of experimental research the location of CCS where it has the greatest to input parameter, i.e. petroleum products humidity, was determined. For greater efficiency and to reduce the overall dimensions, it is better to use one power supply source, than two sources. Having examined VCC of FCPH, it was determined that the most optimal supply mode for the circuit is U_1= U_2=1,25 V.

Fig. 3 shows the variation of voltage value of humidity converter initial signal, depending on time in Orcad Family Release 16.0 environment, at different values of CCS C_W =45 pF Fig. 3a and C_W =180 pF Fig. 3b, supply voltage being U_1= U_2=1,25 V. If C_W =45 pF the frequency of initial signal F=1260 кHz, and if C_W =180 pF the frequency of initial signal F=1040 кHz.



a)



b)

Fig. 3. Variation of initial signal voltage value on time

Fig. 4 shows experimental block-diagram of measuring unit, intended for investigation of FCPH initial frequency dependence on the humidity of petroleum products.

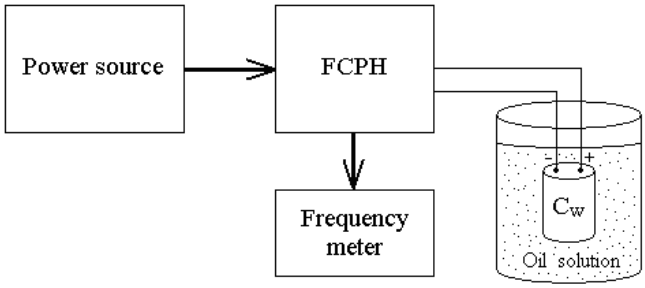
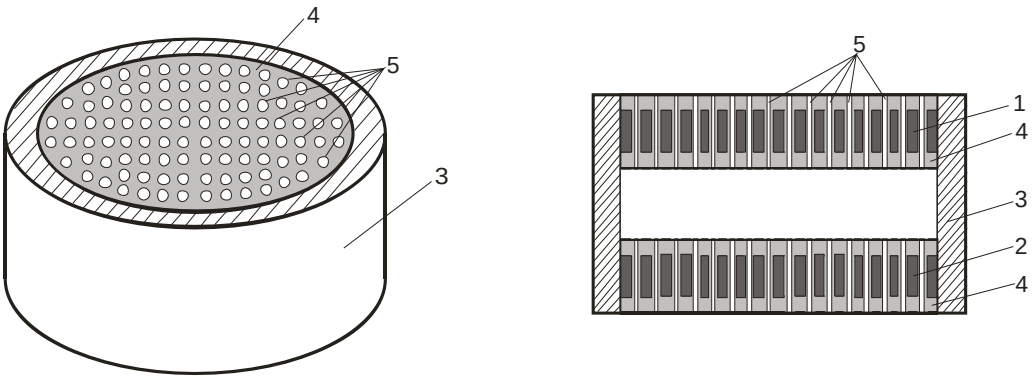


Fig. 4. Block-diagram of measuring unit, intended for investigation of the dependence of converter generation frequency on petroleum products humidity

Humidity-sensitive CCS, shown in Fig. 5 was used in measuring unit. CCS consists of grid-like electrodes, located one against another in such a way, that holes location in the first electrode coincides with holes in the second electrode [5]. Electrodes 1 and 2 are tightly fixed in dielectric tube 3, they are covered by the layer of polymer 4 and contain holes 5, intended for motion of liquid flux, having dielectric properties. External diameter of dielectric tube equals 50 mm, and the distance between electrodes is 15 mm. For mineral oil «M8B» initial capacitance at the given geometric dimension and at zero humidity W=0% equals 20 pF, where as at W=30% – 44,5 pF.

CCS operates in the following way. While motion of the liquid flux across the dielectric tube, where humidity-sensitive capacitance sensor for humidity measurement is installed, liquid through holes 5, fills the space between electrodes 1 and 2, these electrodes are covered by the layer of polymer 4 and are tightly fixed in dielectric tube 3. This causes the change of dielectric permittivity

of humidity capacitance sensor. Depending on variation of the humidity of the liquid being measured, its dielectric permittivity changes, thus, the capacitance of humidity sensor changes too.



a) b)

Fig. 5. Humidity-sensitive capacitance sensor for measurement of petroleum products humidity [5] general view (a), cross-section (b): 1, 2 – electrodes; 3 – dielectric tube; 4 – polymer layer; 5 – holes

In the given case, the dependence of generation frequency on mass humidity of mineral oil "M8B" was investigated. While experimental research of generation frequency F dependence on the humidity of mineral oil «M8B» it was determined that the frequency of input signal F decreases from 1368 кHz to 1262 кHz (Fig. 6) if mass humidity varies in the range of W=0% to W=30%.

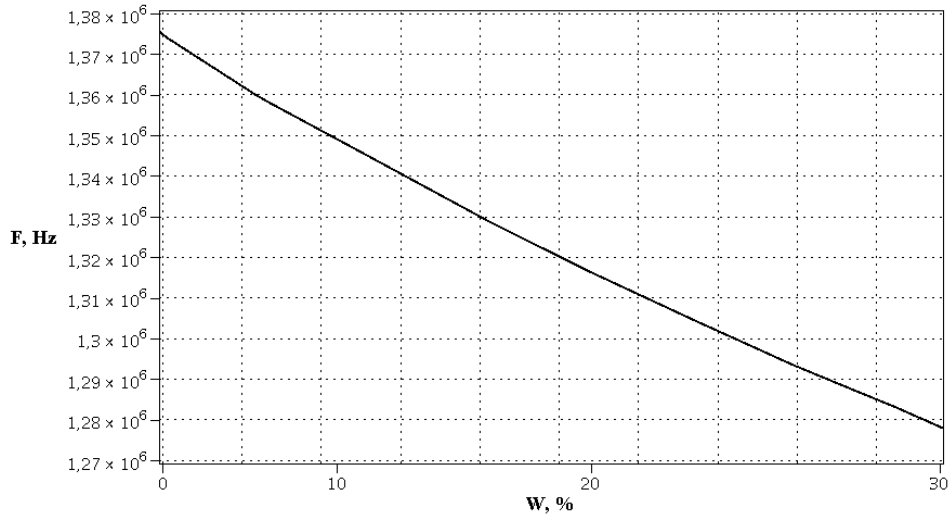


Fig. 6. Experimental dependence of generation frequency on mineral oil «M8B» humidity

For determination of the sensitivity of microelectronic converter of petroleum products humidity we will apply section-linear approximation for transfer function. Sensitivity of humidity converter is 3 кHz /%, while humidity variation is from 0% to 20%, and in the range of humidity variation from 20% to 30% sensitivity equals 4,5 кHz /%.

Conclusions

The possibility of FCPH creation, based on transistor structure with negative resistance in combination with humidity sensitive condenser cylindrical structure is shown. Experimental function of FCPH conversion is obtained. Sensitivity of the developed humidity converter while humidity variation from 0% to 20% is 3 кHz /%, and in humidity variation range from 20% to 30% it equals 4,5 кHz /%.

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