Electronic Hydrostatic Transducer with Digital Output

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***Abstract* – The TPH-485-0,06 submersible level transducer of hydrostatic pressure is a general-purpose sensor for measuring the level of fresh water or other mildly corrosive liquids.**

The TPH-485-0,06 submersible level transducer can be used to measure the water level in reservoirs, lakes, open flow channels, and weirs as well as the groundwater level of boreholes.

Relatively low water levels can be measured using the TPH-485-0,06 submersible level transducer despite its diameter of 24 mm. This is possible by incorporating a highly sensitive miniature silicon diaphragm with a very thin isolation membrane back filled with silicone oil.

***Key words* – hydrostatic pressure transducer, groundwater level of boreholes, RS-485 interface**

I. INTRODUCTION

The urgency of measuring changes in the level and temperature of liquids in wells and tanks has led to the necessity to develop a high-precision hydrostatic transducer.

Hydrostatic level transducers are devices that can monitor and control the level of liquid (water, oil, fuel, etc.).

A long-term monitoring of water level and temperature in reservoirs, water storage basins, lakes, rivers, and geotechnical boreholes is of greatest interest for Moldova.

II. MAIN BODY

At present, pressure transducers that use integrated sensing elements based on single-crystal silicon are the most in demand. This is caused by the fact that silicon converters have an order of magnitude higher temporal and temperature stability, low hysteresis, high sensitivity and repeatability as well as high dynamic characteristics, which make it possible to respond to rapidly changing pressure at a high rate.

Therefore, to design a highly sensitive hydrostatic transducer, we selected a Honeywell excess pressure module as a sensing element. The module has a passive compensation for zero drift and output signal in the range of operating temperatures of 1 to 80°C.

A transducer design was developed, and a prototype was prepared. The transducer is a leakproof construction that consists of a sensitive pressure module, a measuring unit, and a metal case. The measuring unit includes an analog-digital converter (ADC), a microcontroller, and an RS-485 interface driver. Via a four-wire flat cable, the pressure module is connected to a circuit of amplification and processing of electric signals. An access hole is made in the base of the module for the interaction of the back side of the transducer's membrane and the atmosphere. Via a leakproof inlet, a special cable is connected to the outlet of the electronic unit. The cable contains wires for connection via the RS-485 interface, wires for supplying power, a screen, cores for suspending, and an air-operated channel for equalizing the pressure of the nonoperating side of the sensitive element with atmospheric pressure. A cable with a length of 20 m was used.

Fig. 1. Physical configuration of the TPH-485-0,06 transducer.

The hydrostatic pressure exerted on the isolation membrane of the pressure module and the temperature of the case are converted to analog electrical signals. Further, the signals are transmitted to a precision multichannel analog-digital converter with a built-in instrumentation amplifier that provides a high degree of resolution. After the amplification and conversion to digital code, the signals from the ADC come to the microcontroller. The programming of the microcontroller and the program correction are performed through a separate access connector.

Below, we represent the electronic circuit diagram of the transducer.

Here DD is the pressure transducer; Dt is the temperature transducer; ACD is the precision multi-channel analog-digital converter; Mp is the microcontroller; RS485 is the RS-485 interface converter; Uref is the reference-voltage source; St is the voltage stabilizer; Con1 is the connector for power supply and digital data transmission; Con2 is the access connector for programming the microcontroller; and P atmosfer is the air-operated channel for the interaction with the atmosphere.

The microcontroller provides an additional compensation for temperature zero drift and measurement range using information from the temperature transducer, which is in contact with the case of the transducer.

In addition, using the developed program, the microcontroller performs the linearization of the calibration

characteristics of the pressure module, the normalization of measured signals, and the output of data in different units of measurement: in kPa and mm of water column for pressure and in degrees centigrade for temperature. Corrected data are further transmitted via a noise immune RS-485 interface in the format of the Modbus RTU industrial communication protocol for devices of the collecting and recording of measured environmental parameters.

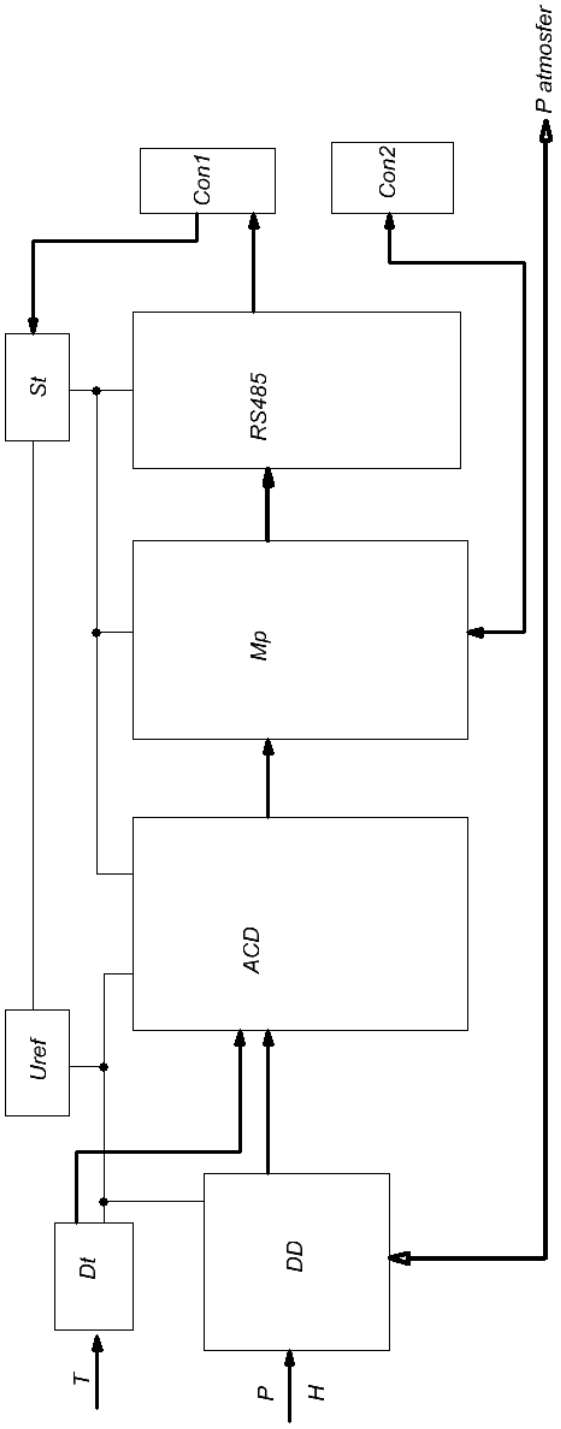

Fig. 2. Electronic circuit diagram of the transducer.

This protocol is open and has already become a de facto standard for the industry of digital devices. According to

Fig. 3. TPH-485-0,06 transducers with a cable and a coil.

TABLE 1. COMPARATIVE SPECIFICATIONS FOR THE PROTOTYPE OF THE TPH HYDROSTATIC TRANSDUCER AND THE DL/N LEVEL CONVERTER

Parameters	Units of meas.	TPH	DL/N
Measured excess pressure kPa	kPa	0 ÷ 100	0 ÷ 10 0 ÷ 2500
Water level	mm H_20	22÷10000	0 ÷ 1000 0 ÷ 250000
Operating temperatures	°C	5 ÷ 50	-5 ÷ 50
Measured temperatures		1 ÷ 85	-5 ÷ 50
Interface	Digit.	RS-485	RS-485
DC supply voltage	V	4 ÷ 6	Li-bat. 3,6 ≤100m – 1 b. >100m – 2 b.
Power consumption	mW	≤ 120	-
Current consumption	mA	≤ 20	-
Basic percentage pressure error	% /FS	≤ 0.02	0.1
Basic temperature error	°C	≤ 0.2	+/- 0.25
Communication protocol	-	Modbus RTU	-
Zero drift in the range of operating temperatures	Pa	≤ 20	-
Absolute pressure error	Pa	≤ 10	-
Absolute level error (10 to 40°C)	mm H_20	≤ 1	-
Resolution	Pa	≤ 2	-
	mmH_20	≤ 0.2	-
Dimensions	mm	Ø 32x185	Ø24×205
Weight	kg	≤ 0.45	0.56
Cable	m	Order	≤ 300
Protection class	-	IP68	IP68

experts, more than 40% of the applications of industrial data exchange use the Modbus protocol for the communication between objects. In addition to this, it should

be noted that almost all modern SCADA-systems support this communication protocol.

Engineering tests of the prototype of the TPH-485-0,06 transducer with a cable and a coil were performed; the results are shown in Table 1. The table also lists the specifications of one of the best analogues, i.e., a DL/N high-precision hydrostatic transducer (STS, Switzerland). Comparing and analyzing the engineering data of the TPH and DL/N transducers, we can state for certain that the basic percentage pressure error for the developed transducer is almost 5 times less than that of the DL/N transducer. This will make it possible to determine the change in the water level in boreholes with an accuracy better than 1-2 mm H_2O.

The exchange of data on water level and transducer temperature with the information system is carried out via an RS485 interface (Modbus RTU protocol). Using a system of data collection and transmission via the GSM network, it is possible to monitor the condition of wells and reservoirs in real time scale, which will give the possibility to rapidly respond to changes in the level and temperature of groundwater.

III. CONCLUSIONS

In conclusion, we can note that the developed TPH hydrostatic transducer is more precise in comparison with counterparts; this will make it possible to study changes in water level in wells and reservoirs and to use this transducer in water level observations in wells for finding hydro-geodynamic earthquake precursors in the republic.

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