Electronic Pressure Transducer with Digital Output

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***Abstract*—The TP22E gage pressure and temperature transducer consists of a primary pressure transducer, fittings with an M20x1.5 standard connection to the measured medium and a built-in pressure modulus with a metal isolating diaphragm, an electronic unit with an indicator enclosed in a single metal case, and a plug. The TP22E transducer is designed for continuous conversion of the pressure of the measured medium to a digital signal of the RS-485 interface (ModBus protocol) and a standardized DC signal of 4–20 mA. The measured pressure values are displayed on a six-digit LED indicator. The transducers are utilized in automated process control systems in various branches of industry, such as the gas, chemical, food, pharmaceutical industries, power engineering, water purification, etc.**

***Index Terms* — temperature, digital, pressure, control, RS-485 interface**

I. INTRODUCTION

The necessity to develop gage pressure transducers is caused by the need for converters intended for measuring the pressure in industrial plants, in particular, in the equipment of the gas and food industry with displaying the information on a digital device or controller in automated process control systems.

II. DESCRIPTION OF THE TRANSDUCER

The pressure transducer is based on the principle of converting a mechanical quantity, i.e., pressure, to an electrical signal. The measured pressure is applied to a flexible metal membrane which passes it through a polymer liquid to the membrane of a sensing element (SE) prepared of single crystal silicon. This material is selected because silicon transducers have a high sensitivity and reproducibility, a low hysteresis, and good dynamic characteristics, which make it possible to quickly respond to the rapidly changing pressure. A bridge circuit, which converts a pressure change to an electric signal in the form of a Wheatstone bridge offset, is formed on the SE membrane.

To compensate for the span thermal error (STE), the bridge circuit of the SE is powered by a source of stable current. In addition, the SE exhibits the pattern of change in the resistance of the bridge which reduces the STE to a negligible value owing to the effect of self-compensation.

The elimination of the initial offset of the SE bridge and compensation for its thermal error (TEUo), which is characteristic of semiconductor sensors, are implemented on an additional board, which has an electrical and thermal contact with the base of the pressure module. An integral temperature transducer that transmits data on the current temperature of the pressure modulus is located on the same board. The residual and complementary temperature error and the nonlinearity of the converting characteristic are minimized in the electronic circuit with the aid of software.

The design of the transducer was developed, and a prototype was prepared. The transducer is a leakproof construction consisting of a sensitive pressure module, a measuring unit, a metal case, and an electrical connector. The measuring unit includes a precision analog-to-digital converter (ADC) with an amplifier, a source of a highly stable current, a microcontroller with a six-bit graphic LED display, an RS-485 interface driver, a digital-to-analog converter (DAC) for generating an analog standard signal, and push-button controls. The front side of the case has a transparent window for visual inspection of the measured pressure and temperature.

The physical form of the TP22E gage pressure and temperature transducer is shown in Fig. 1.

The pressure of a gas or liquid column which is exerted on the isolating diaphragm of the pressure module and its temperature are fed, in the form of analog signals, to the precision multichannel ADC with a built-in instrumentation amplifier. After amplification and conversion to a digital code, the signals from the ADC come to a PIC24 microcontroller

The microcontroller is programmed through a separate technological plug inside the case. The push- buttons provide switching on the display, accessing the user menu, reranging the output analog signal, and, if necessary, changing the units of measurement.

A digital signal can be integrated from some pins of the electrical plug connector located on the case through a commercial RS485 interface into a remote measurement system via transmitting through a twisted pair of wires.

A 4-20 mA standardized analog signal is transmitted from other plug pins, regardless of the digital channel, through a twisted pair of wires.

Fig. 1. Physical form of the TP22E transducer.

Figure 2 shows the electronic circuit diagram of the transducer.

The microcontroller provides additional compensation for temperature zero drift and the measuring range using the information from the temperature sensor 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 the measured signals, and the output of data different units of measurement: in kPa for pressure and in degrees centigrade for temperature. The corrected data are further transmitted via a noise immune RS-485 interface in the format of the Modbus RTU industrial communication protocol to a device intended for the storage and recording of the measured environmental parameters.

The following notation is used in Fig. 2: DD, pressure sensor; Dt, temperature sensor; ACD, precision multichannel analog-to-digital converter; Mk, microcontroller; RS485, RS-485 interface converter; Uref, reference-voltage source; DAC, digital-to-analog converter; Iconst, stable current source; St, voltage stabilizer; Con1, plug connector for power supply and digital data transmission; Con2, technological plug connector for programming the microcontroller; Kn1 and Kn2, controls on the transducer; Indicator, multidigit LED display.

This protocol is open and has already become a de facto standard for the industry of digital devices. According to experts, more than 40% of applications of industrial data exchange use the Modbus protocol for communication between objects. In addition, it should also be noted that almost all modern SCADA-systems support this communication protocol.

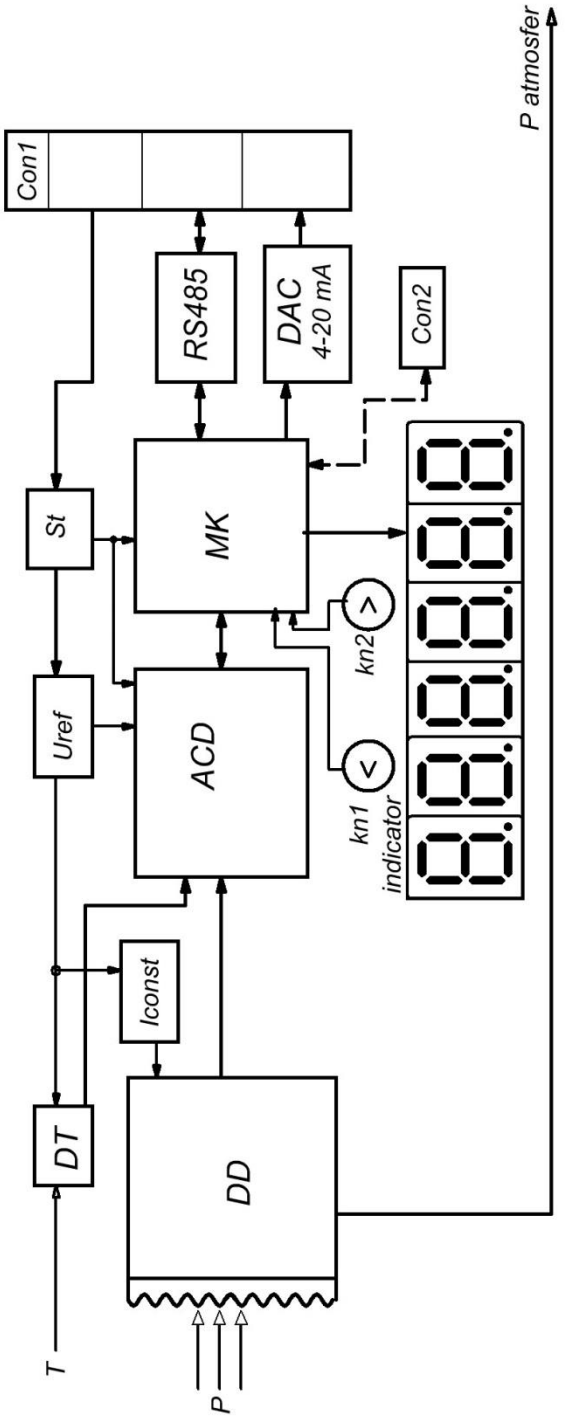

Fig. 2. Electronic circuit diagram of the transducer.

The prototype of the TP22E transducer was subjected to engineering tests, which revealed the following technical characteristics of the transducer:

- The measured pressure range is 0 to 0.016 MPa.
- The maximum permissible error does not exceed 0.15% of the upper-range value.
- The operating temperature range is –20 to 70ºC.

- The transducer has a ramp response of the output signal with the limiting value of the output signal of RS-485 interface of ModBus protocol (ASCII) and/or 4-20 mA (according to the order).
- The DC voltage is 12–24 V.

The TP22E pressure and temperature transducer is in line with the counterparts of the leading companies in the world.

The exchange of data on gage pressure and temperature of the transducer with the information system is carried out via the RS485 interface (Modbus RTU protocol). Using a system of data storage and transmission via the GSM network, it is possible to monitor the state of objects and equipment in real time scale, which will give the possibility to rapidly respond to changes in process parameters.

CONCLUSIONS

TP22E gage pressure transducers with digital and analog outputs are designed to control the gas pressure in urban distribution networks and are used in systems of automatic monitoring, adjustment, and control of industrial processes. In addition, it is recommended to use them in housing and public utilities, power engineering, metallurgy, and in the chemical and food industries. The most promising application is expected at the Moldova Gaz company.

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