Smart transducer with radiomodem

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Abstract. Systems for measuring different parameters enabling metering and wireless data transmission are an urgent problem in the industry. One of the most promising solutions is the developments of metering instruments enabling radio-link and GSM data transmission. The article describes a transducer operating with temperature sensors of different types as well as with the sensors of other physical values with the output signal represented as current or voltage with subsequent measurement data transmission from the transducer to the computer via radio-link. The article provides transducer measurement accuracy check. The work confirmed the claimed temperature measurement accuracy, noted a stable data transmission via radio link and convenience of work with the transducer and software.

1. Introduction
At small and large plants and industrial systems it is always necessary to supervise the processes by means of monitoring of physical values, such as temperature, pressure, flow rate etc. which entails the production rigging with the physical value data, auxiliary metering equipment and, consequently, communication lines for the signal transmission from the sensor to the meter and then to the control room etc.

The signal wired transmission has disadvantages, both engineering and economic:
- Signal transmission line purchase and assembly costs;
- Short signal transmission distance;
- Impossibility of connecting all the lines to one control room;
- High concentration of wired lines in the production premises, especially, if the signal transmission redundancy is required;
- Difficulties in the wire laying and assembly in hard-to-access and hazardous locations.

To eliminate these disadvantages it is appropriate to apply equipment with wireless data transmission links.

2. Problem description
The work objective is review of smart transducers with radio modem, discussion of its specifications and check. To attain the target set it is necessary to solve the following problems:
- Review the instrument and its specifications;
- Check the instrument measurement error;
- Check the signal instrument-to-PC transmission stability.

3. Theory
The smart transducer with radio modem (hereinafter referred to as the STRM) is designed for measuring the temperature and other physical values with subsequent data transmission to the
computer via radio link. The transducer will enable continuous monitoring of the processes measured as well as supplying alarms of the critical values of a certain parameter to be measured.

The STRM is a small metal box with three cable inputs, two of which being measurement channels and the third one – for power supply. Outside the housing there is also a small antenna (Figure 1).

![STRM Visual Appearance](image1)

*Figure 1. STRM Visual Appearance*

Inside the transducer there are terminals of interchangeable measurement channels to which sensors are connected and a power supply terminal (Figure 2).

![STRM Internal View](image2)

*Figure 2. STRM Internal View*
Both the transducer channels may operate with the following thermocouple types: ПП(S), ПР(B), ЖК(J), ХА(K), ХК(L) [1], and with the following resistance thermometer types: 50П, 100П, Pt50, Pt100, 50М, 100М [2], as well as with the current signal 4-20 mA and voltage 0-5 V and 0-10 V which makes a STRM a universal transducer capable of operating with any sensors of various physical values with a unified output signal.

Table 1. Basic specifications are provided in the table

| Output Signal Type | Output Value Measurement Range | Unit of Measurement | Limits of the Basic Value Admissible Value, % |
|--------------------|--------------------------------|---------------------|-----------------------------------------------|
| ПП(S)              | From 0 to +1750 °С             | °С                  | 0.5                                           |
| ПР(B)              | From +600 to +1700 °С          |                     |                                               |
| ЖК(J)              | From -100 to +1200 °С          |                     |                                               |
| ХА(K)              | From -100 to +1300 °С          |                     |                                               |
| ХА(L)              | From -100 to +600 °С           |                     |                                               |
| 50П                | From -100 to +750 °С           |                     | 0.2                                           |
| 100П               | From -100 to +200 °С           |                     |                                               |
| Pt50               | From -100 to +750 °С           |                     | 0.2                                           |
| Pt100              | From -100 to +200 °С           |                     |                                               |

Data transmission from the transducer to the computer is performed by radio link at the distance up to 1.5 km.

STRM’s may be joined in a uniform network with the number of up to 50 instruments (Figure 3). This function enables simultaneous monitoring of the parameters at the objects involved in various processes and warn the operator of the change in the physical value measured outside the user-set limits.
The main window of the software for operating МИРС Transducer (Measurement radio network manager) is a device manager (Figure 4), this window displays serial numbers of the instruments connected, their status, indication of the measured value excursion outside the limit set, the communication signal level and line for the comment input to each instrument.

Then follows channel setting window (Figure 5) in which for each channel the sensor type connected to the channel is set or the ratio of the unified signal and value measured as well as values of the parameters for the emergency alarms are set.
There is also a function of displaying these data in real-time chart (Figure 6) which enables obtaining radically new information of the current processes.
4. Experiment

SRTM measurement error was checked. The measurement error was checked during the operation with the thermocouple and resistance thermometers. The thermocouple measurement error was checked as per the diagram provided in Figure 7, resistance thermometer measurement error was checked as per the diagram provided in Figure 8.

![Figure 7. Check Diagram with the Thermocouple](image)

![Figure 8. Check Diagram with the Resistance Thermometer](image)
As per the diagram provided in Figure 7 thermal EMF was reproduced as per the rated static characteristic for ТЖК type thermocouple. As per the diagram provided in Figure 8 resistance boxes were used to reproduce the 100П type resistance thermometer rated static characteristic. After the measurements the measurement error was calculated as per equation 1.

\[ \Delta T = \left( \frac{T_{\text{max}} - T_{\text{in}}}{T_{\text{max}} - T_{\text{min}}} \right) \times 100\%. \] (1)

5. Experiment Results
The measurement and calculation results are provided in Table 2 and 3.

**Table 2.** Error in case of thermocouple operation

| T, °C | \( V_{\text{init}}, \text{mV} \) | STRM Readings, °C | ΔT, °C | ΔT, % |
|-------|-----------------|------------------|--------|-------|
| -100  | -4.633          | -98.54           | 1.46   | 0.11  |
| 0     | 0.000           | 1.08             | 1.08   | 0.08  |
| 100   | 5.269           | 100.88           | 0.88   | 0.07  |
| 200   | 10.779          | 200.92           | 0.92   | 0.07  |
| 300   | 16.327          | 300.96           | 0.96   | 0.07  |
| 400   | 21.848          | 401.00           | 1.00   | 0.08  |
| 500   | 27.393          | 501.04           | 1.04   | 0.08  |
| 600   | 33.102          | 601.08           | 1.08   | 0.08  |
| 700   | 39.132          | 701.12           | 1.12   | 0.09  |
| 800   | 45.494          | 801.15           | 1.15   | 0.09  |
| 900   | 51.877          | 901.28           | 1.28   | 0.1   |
| 1000  | 57.953          | 1001.40          | 1.40   | 0.11  |
| 1100  | 63.792          | 1101.46          | 1.46   | 0.11  |
| 1200  | 69.553          | 1201.50          | 1.50   | 0.12  |

**Table 3.** Error in case of resistance thermometer operation

| T, °C | \( R_{\text{init}}, \Omega \) | STRM Readings, °C | ΔT, °C | ΔT, % |
|-------|-----------------|------------------|--------|-------|
| -100  | 60.26           | -100.02          | -0.02  | -0.0024 |
| -50   | 80.31           | -50.050          | -0.05  | -0.0064 |
| 0     | 100.00          | -0.040           | -0.04  | -0.0052 |
| 50    | 119.40          | 49.95            | -0.05  | -0.0059 |
| 100   | 138.51          | 99.95            | -0.05  | -0.0059 |
| 150   | 157.33          | 149.94           | -0.06  | -0.0071 |
6. Discussion of Results
The transducer in question has the required measurement accuracy, it enables measurements from two sensors of different types and the data transmission to the PC without radio link communication. Therefore, this instrument may be used both as a redundancy system and a the main measurement system for the monitoring of different physical values.

7. Conclusions
1. The transducer presented enables operating with different temperature sensors as well as sensors of other physical values with a unified output signal.
2. The transducer enables measurements from a large number of sensors without signal transmission line laying and using one PC.
3. The instrument measurement error does not exceed the claimed accuracy ranges.
4. These transducers with wireless communication are becoming more and more popular due to their operation convenience and possibility of large-distance measurements without expenses for wired data transmission lines.

References
[1] GOST R 8.585-2001. 2010 State system for ensuring the uniformity of measurements. Thermocouples. Nominal static characteristics of conversion. Superseding GOST R 50431-92; made effective on 30.06.2002 (Moscow: Standartinform).

[2] GOST 6651-2009. 2011 State system for ensuring the uniformity of measurements. Platinum, copper and nickel resistive temperature transducers. General technical requirements and test methods. – Superseding GOST 6651-94; made effective on 01.01.2011. (Moscow: Standartinform)