The Adaptational Procedures Applied in Microprocessor Measurement Channel

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Abstract-In this paper the configuration of the test measurement channel for examination of the adaptational algorithms is presented. The measurement channel additional units and auto-calibration algorithms enable to designee its actual characteristics in operation condition and finally to perform the correction of measurement result as well as the assessment of its uncertainty. The basic idea of concerned procedure were shown in [1].

I. Introduction

In the operation practice, the assessment of accuracy of the measurement results brings still to the instrument user a lot of problems. Some of them are connected with difficulties of determination of measurement conditions, influencing on measurement process, another are owing to quite complicate algorithms to be done for result uncertainty designation, because of many factors to make allowance for. In [1], the concept of engagement to the functions fulfilled in measurement microprocessor instrument the additional tasks connected with result uncertainty assessment was presented.

The input of measurement channel, containing analog and digital part, is supplied during calibration with signal generated using standard, linearly rising $u_w(t)$ voltage (Fig.1). The samples of input signal are taken with τ sampling step and converted to their digital representation. On the output of analog-to-digital converter (ADC), the series of **Y** digital representation of instantaneous values of channel input signal, is obtained ({**Y**} file). As a result, the value of several elements of {**Y**} file depends on interacting factors, violating the channel characteristics and measurement process.

Applying the linear regression method, the **Y'** elements of {**Y'**} digital file can be designated (Fig.1). They represent the **actual** characteristic of measurement channel.
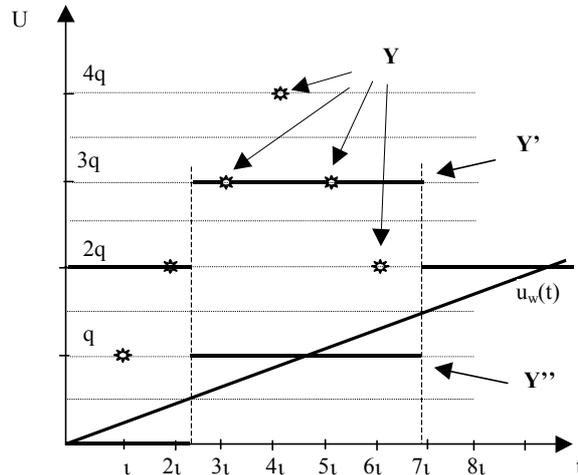

Figure 1. Digital representation of converted input signal for *ideal* and *actual* characteristics of measurement channel

On the base of rising time of $u_w(t)$ standard signal, which is changing in whole range of channel characteristics, the Y'' elements of {**Y''**} digital file are calculated by microprocessor. That file determines the digital representation of **ideal** characteristics of tested channel, assumed by instrument designer. The comparison of {**Y'**} and {**Y''**} files enables to execute the measurement result correction, by removing systematical interaction effects causing the channel characteristics changes (characteristics error). The dispersion of {**Y**} file elements in relation to {**Y''**} file elements can be used to determining of measurement result uncertainty following rules described in [2, 3, 4].

The relations between digital data files **{Y}, {Y'}** and **{Y''}** during performing of adaptational procedure are shown in Fig.2.
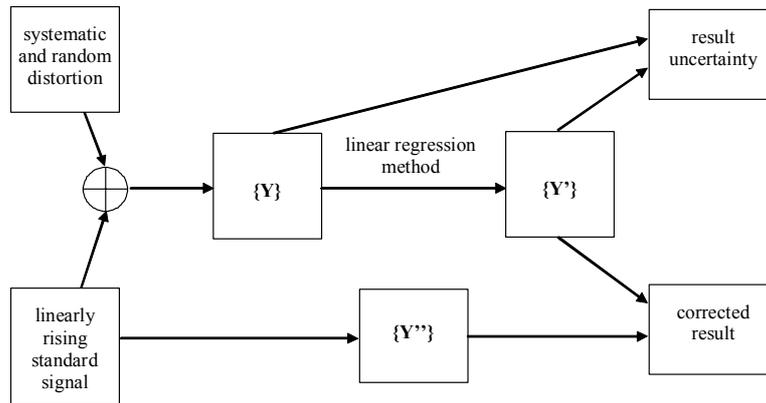

Figure 2. The adaptational procedure of improvement of measurement accuracy

II. The adaptational properties of measurement instrument

The measurement instruments are designed to perform some specified measurement functions. The microprocessor technology enables designing the multi-functional instruments. In such instrument, the measurement algorithms are the significant part of measurement channel. For common hardware structure of instrument, the performed measurement function depends on actually selected algorithm fulfilled by microprocessor program. The configuration of typical microprocessor measurement channel is shown in Fig.3. The signal part (*data acquisition*) of the measurement channel contains the analogous circuitry (including: input circuits, separation sets, sets normalising the signal) and the analogous-to-digital (*ADC*) converter. This part is applied to perform the analogous input x measurement signal conditioning. The output data, in the form of digital words Y, undergoes processing in the software part (*data estimation*) of the measurement channel according to the algorithm corresponding to a chosen measurement function.
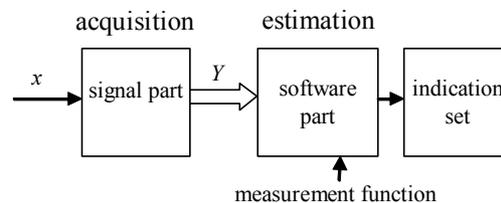

Figure 3. The functional structure of measurement channel

For specified measurement function, the resultant characteristics of both acquisition and estimation parts of channel are the implementation of the respective mathematical model of measurement process [1, 2]. It is assumed, that both mentioned parts of measurement channel follow the model. It is fulfilled in *ideal* conditions. In instrument *operation* conditions, the external random or systematic influences affects fundamentally on circuits and signals in *acquisition* part of measurement channel. As a result, the channel characteristics can be changed and measurement result can differ more from the true value and also the measurement accuracy is worsening. On the other hand, it is admissible to assume, that the data computation of Y words in *estimation* part of measurement channel is fully independent on the influence of external disturbances. In that part, the another ingredients of result uncertainty appear, e.g.: connected with rounding or approximations of computed data, resolution of indicating unit. The instrument operator makes the measurement result read-outs and he is obliged to assess the accuracy, dependently on external influences. In such conditions, the proper assessment of result accuracy seems to be often the difficult task, often exciding the abilities of instrument user.

The implementation of microprocessor technology in construction of various measurement instruments allows realising many additional functions besides the basic measurement functions for a given type of instrument. For these instruments, there is a wider range to built up the adaptational properties connected with the change of specific parameters used in process of result estimation in reference to the variable measurement conditions. Such technology makes the possibility to build into the software

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of an instrument the algorithms for the identification of actual courses of its conversion characteristics, dependably on influencing condition. Taking into consideration the results obtained during channel examining process as well as mathematical model of channel, the uncertainty of measurement result assessment is to carry out as the instrument internal procedure. This way, the measurement result uncertainty can be also available to the instrument operator as the supplement to the measurement result. It can be especially useful according to multifunctional instruments, where for each measurement function the assessment of uncertainty requires a separate approach. The parameters of algorithm connected with measurement data estimation are adapted according to information about the actual characteristics of measurement channel and, indirectly, to the influence of external disturbing factors.

The implementation of such kind of the adaptational properties to the measurement instrument is to perform by applying additional units as well as adequate algorithms enabling the designation of the actual characteristics of measurement channel. Additional unit has to provide the channel input with the standard signals to perform the channel auto-calibration procedure. During this procedure the channel is examined, how it transmit well-known signals from its input to output of *acquisition* part. The results of examination depend on channel characteristics and also on level of environmental disturbing factors influencing the instrument functioning.

III. The configuration of measurement channel under test

Auto-calibration of measurement channel means that the instrument contains additional circuits and software to support calibration without any user intervention [2]. The calibration procedure is managed by microprocessor program procedure, which controls the auto-calibration progress, determines the best settings, and stores them in memory. In such situation, some procedures connected with the standardisation of the instrument would be moved from a legalisation laboratory to the instrument. In the laboratory, only the standards used in the instrument would be checked (e.g.: V_{ref}, I_{ref} standard sources). The results of checking are stored in the form of the appropriate parameters in the instrument memory. This way the channel stays in calibration over its entire operating life.

The design goal of channel auto-calibration is to correct its characteristics for drift errors that occur over time and temperature or another disturbing factors. The typical connection of auto-calibration unit to the measurement channel is shown in Fig.4.
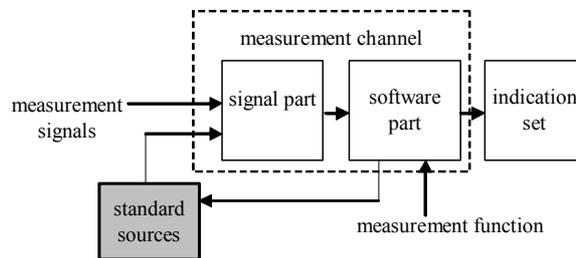

Figure 4. The connection of auto-calibration unit to the measurement channel

Several instruments are equipped in various type of auto-calibration units. A simple auto-calibration circuit (Fig.5.a) alternately switches the channel input to zero scale to correct offset drift, and to full scale to correct gain drift. Hardware solutions or software procedures are used to correct the channel characteristics accordingly. Precision resistive dividers (Fig.5.b) are often used to generate the representative voltages reasonably close to full scale. Each divider requires a separate multiplexer channel to apply its output to the measurement channel input, increasing system complexity.

Instead of such complicated structures (Fig.5.b), the simple multi-point standards voltage source is proposed [1]. The electrical diagram of linearly rising standard voltage generating unit is presented in Fig.6. This unit is the part of the testing unit, shown in Fig.7, equipped with considered auto-calibration module, two measurement channels and based on TSm module (Target Socket module) supported by Texas Instruments MSP430F149 microprocessor. The test unit (Fig.7) is connected with *PC* computer using JTAG interface. The software tools for microprocessor resources debugging, installed in *PC*, enable designing and assembling the measurement microprocessor program, locate them in internal microprocessor flash memory and run under control of designer. The test unit is currently being examined. The preliminary results of testing are promising. The further research of instrument is pointed on the optimization of procedures connected with designation of measurement channel characteristics and using obtained information to improve the measurement process, adaptationally, to do the instrument functioning correct and independent on disturbing factors in wider range of usage.
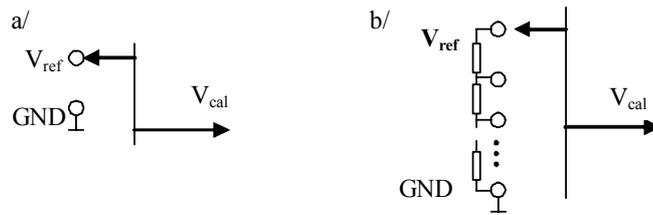
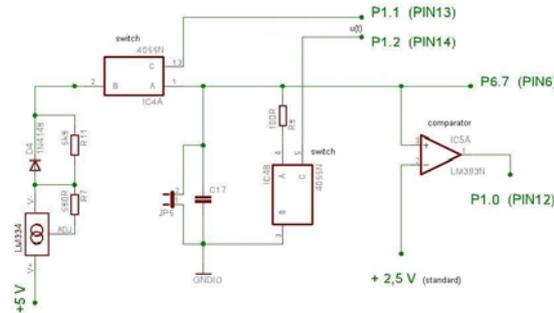Figure 5. The typical configurations of auto-calibration circuitry

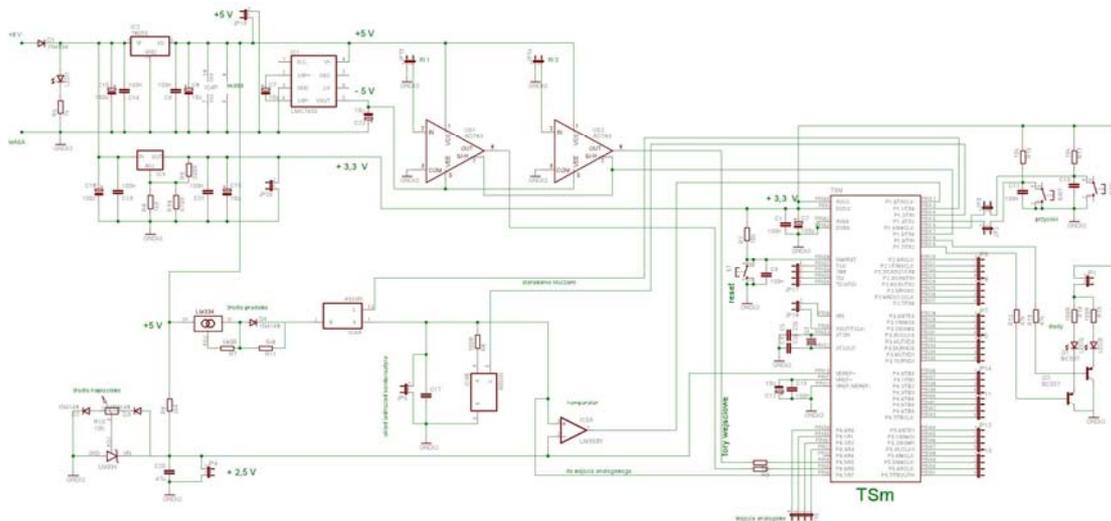Figure 6. The functional diagram of auto-calibration unit

Figure 7. The electrical diagram of test unit; TSm – Target Socket module with MSP430F149 microprocessor

IV. Preliminary conclusions

For many measurement instrumentation users the result uncertainty is still difficult to assign, especially in indefinable ambience condition. Under the operation conditions the instrument user is obliged to result uncertainty designation taking into account instrument producer technical data (usually the accuracy class only). Presented investigations attend to check and optimize of the algorithms of measurement result correction and uncertainty designation applied in microprocessor instrument program.

References

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