Electronic Calibration Station

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Abstract- In digital sampling electricity meters calibration procedure is used to set the parameters of the device and to correct the errors of measurement. Electronic calibration station EKS 05-3, used to calibrate electricity meters, is described and its function is explained. The developed calibration software for the calibration of the designed and constructed PEM 6711 digital sampling electricity meter is also described.

I. Introduction

In digital sampling electricity meters the measurement errors of the analogue input circuits can be simply eliminated in the digital signal processing. Calibration procedure is used to set the parameters of the device and to correct the errors of measurement, [1]. The simplest error correction is only the offset correction, which is done by measuring the value of the input quantity with short-circuited input and storing this value in the memory for use as the correction constant. This error correction is usually accomplished every time the instrument is switched on. To correct the gain error multiplication coefficient must be evaluated. This needs some reference value of the input quantity to be connected to the input and measured by the instrument. The nonlinear characteristic of such an instrument needs more values of the input quantity to be connected to the input and measured by the instrument. In such case, a nonlinear correction function or a table of correction values must be calculated.

In electricity meters, three calibration procedures must be run, [2], [3]: voltage calibration, current calibration and parasitic phase shift correction. The best way is to carry out the calibration process automatically, using a computer. The computer controls a signal source (sets the desired measured values), reads the necessary values from the calibrated and reference instrument in the same instant, calculates the calibration constants and stores them in the memory of the calibrated instrument. Manufacturers of electricity meters usually have such possibility.

The designed instrument, PEM 6711, has an algorithm for the voltage and current calibration using the least squares method. The parasitic phase shift correction is accomplished by shifting the current samples before their multiplication with the corresponding voltage samples to get the measured power value. Calibration equipment used is based on EKS 05-3 electronic calibration station, [4], combined with K2006 precise three-phase comparator, [5], [6], and software developed for control of the calibration process.

II. Calibration Station Description

Electronic calibration station EKS 05-3 consists of these main parts (Figure 1):

- PEM 6711 – digital 3-phase signal generator combined with electricity meter.
- K2006 – precise three-phase comparator (separate instrument).
- Power transformers and amplifiers for 3-phase voltage and current signals.
- Equipment for error evaluation and display.
- Personal computer with control and calculation software.

PEM 6711, [7], is a precise digital electricity meter combined with a 3-phase signal generator. This instrument is used in the electronic calibration station as a reference standard for measurement and generation of the 3-phase test signals (voltages and currents) with sufficient accuracy. It is possible to set the desired phase shifts between the phase voltages and also between the corresponding phase voltage and current. Measuring function of the device makes it possible to stabilize the amplitudes of the generated signals. The accuracy of this electricity meter is 0.05% and it supports the RS-232 interface control protocol.

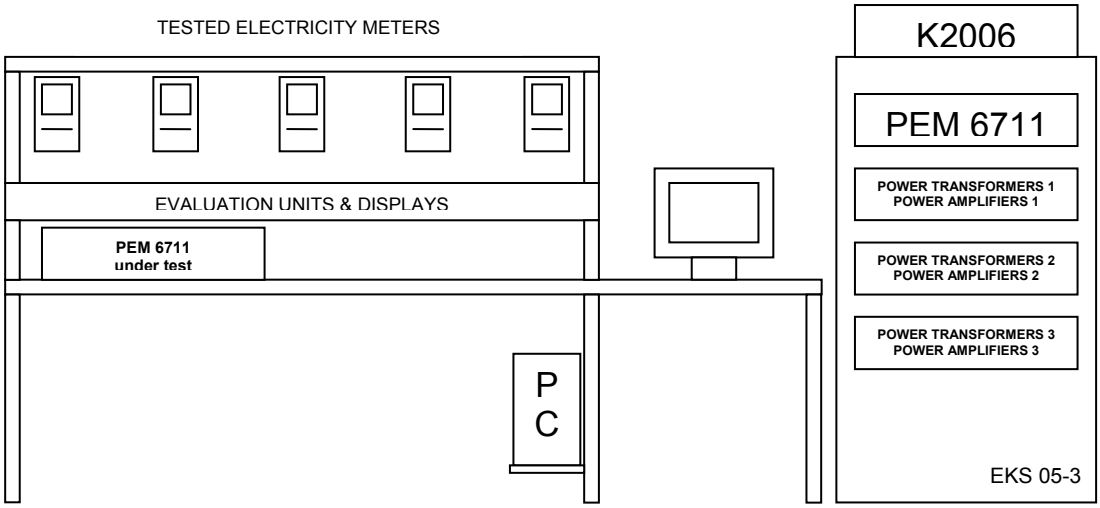

Figure 1. Front view of the electronic calibration station EKS 05-3.

K2006, [5], [6], is a precise three-phase comparator developed for universal laboratory and test use. It is used as a standard meter for precise measurement of calibration values and error calculations based on frequency outputs (if necessary). It can also display the time and phase diagrams for quick orientation in the positions of the generated signals and to calculate and display the frequency spectra of the generated signals. The basic accuracy of the comparator is 0.01 % and the communication via RS-232 interface is also included in its software.

Three fP2200 Lab.gruppen double-channel power amplifiers, [8], [9], amplify analogue signals from the test signal generator PEM 6711. Amplified three-phase signals used as the test voltages and currents are led into the three pairs of toroid voltage and current power transformers, respectively. The transformers enable to set such values of voltages and currents which are impossible directly from the outputs of the amplifiers. These transformers contain secondary windings with a few taps to enable to create different combinations of voltage and current values which are switched to the output by a set of relays controlled via RS-485 interface.

Tested electricity meters are mounted on a bearer, connected to the voltage and current connectors and optical rotation sensors are correctly fastened. The main part here is the evaluation unit. It compares the number of pulses which are proportional to the measured energy counted during one turn of the rotating disk of the electricity meter under test and the number of pulses generated by the reference standard. Calculated error is displayed on LCD display and if it is outside the tolerance interval the electricity meter under test must be adjusted.

The software called MeSta (from Measuring Station) in the PC controls the whole calibration station via multiple RS interfaces. It is used to control the PEM 6711 in the station, the relays and the error evaluation devices. There is also another program named Station to calibrate an external electricity meter PEM 6711 using the K2006 comparator.

First of all, it is necessary to set up the electricity meter for calibration. It consists of choosing the appropriate mode of sensing the tested device and to specify its parameters inside the program. The program MeSta permits to perform many predefined tests on the device following the test prescriptions and to save the results into output protocol.

All tests are based on the generating of the specified voltage and current test signals. EKS 05-3 is able to generate independent three-phase voltage and current signals with the following parameters:

- voltage range: 1 V … 300 V rms,
- current range: 0.01 A … 120 A rms,
- phase range: 0^o … 360^o,
- frequency range: 40 Hz … 60 Hz.

The program MeSta sends appropriate commands into PEM 6711 and relays command unit via RS interface to set their parameters. Amplified test signals enter both the reference standard PEM 6711 and the electricity meter under test. Evaluation unit counts the number of pulses proportional to the measured electrical energy coming from both devices. When the number of pulses coming from the tested device is equal to the predefined amount a flag is set. The program periodically tests this flag (on

all active evaluation units) and reads the measured number of pulses if the flag has been set. Consequently the program calculates the error and sends the result into the display. However, the PEM 6711 has to be calibrated using the K2006 comparator and the software program Station before it can be used as the reference standard.

III. Calibration Software Station Description

The software Station is designed to run under MS Windows operating system. It was realized in C++ programming language, using Borland C++ Builder 6 and the communication of the program via serial port is covered by a C++ Builder's component ComPort.
The program Station was developed to communicate with devices that belong to calibration laboratory via RS interfaces - K2006 comparator, a few PEM 6711 devices and a set of power transformers' relays. Using this program, it is possible to set many parameters of multiple devices centrally from one program before the very operation of calibration.
However, the most useful function of the program Station is to control the automated calibration process of an external electricity meter PEM 6711 based on the K2006 comparator. Program Station enables to calibrate multiple PEM 6711 devices at the same time and what is more, an interface for calibration measurement of universal electricity meters is being prepared. Till now, the process of calibration of PEM 6711 is realized in two stages. The program Station realizes the first one. It enables to define test points for calibration of each measuring range of PEM 6711 into a protocol file.
This includes the following settings for each test point:

- voltages for the selected phases,
- currents for the selected phases,
- phase shifts between voltages and currents for the selected phases,
- number of measurements,
- time spacing between measurements.

Other adjustable parameters are e.g.:

- selection of measured quantities to be saved into a file (voltages, currents, powers),
- name of the directory for the results files to be saved to.

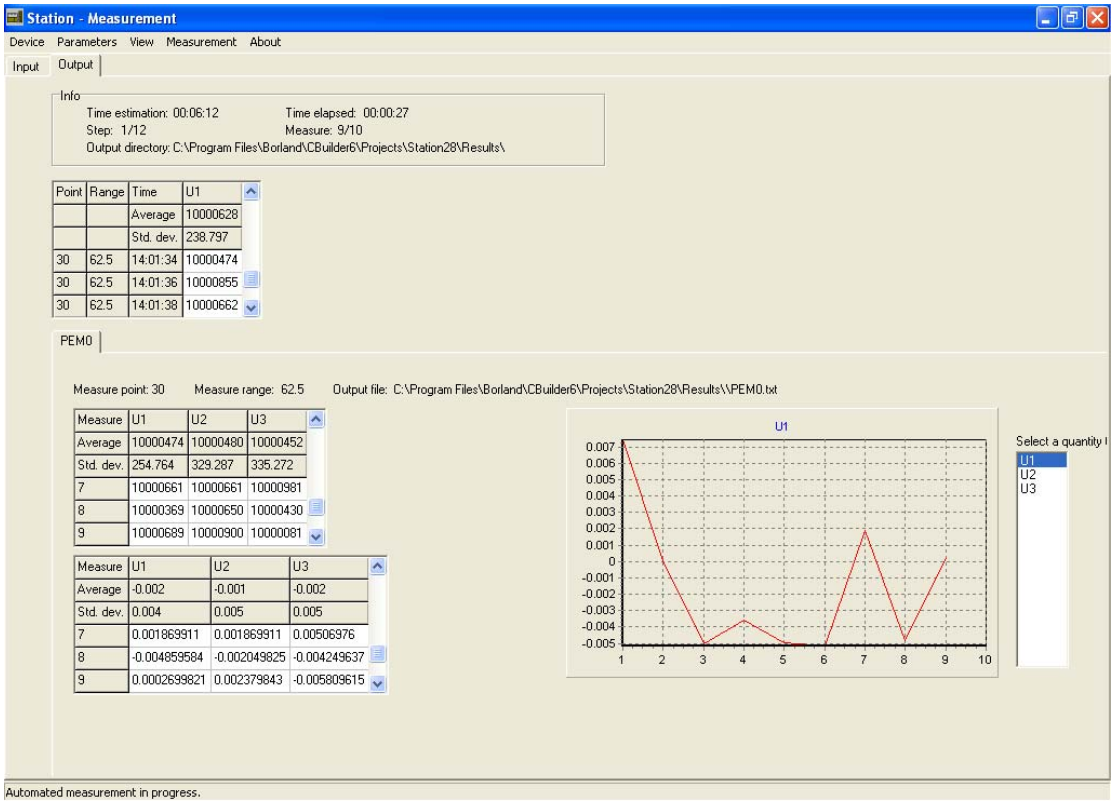

Figure 2. Screen capture of the program Station during an automated measurement (fictive values).

Once the setting is complete an automated measurement is performed. Measured values originating in each tested device together with reference values coming from K2006 device are written into a result text file in a tabular form during the automated measurement. As soon as new values are gathered, the program displays them on the screen and relative errors are calculated and graphically displayed for each tested device, too. The user is informed also about the progress of automated measurement by displaying of the number of the current measure point, the time elapsed from the beginning of the measurement and the time estimation of the total duration of the measurement.
When the measurement is done the second stage of the calibration is realized using a single purpose program utility named Calibration. This tool was designated for processing the measured values that means to calculate calibration constants for each measuring range of PEM 6711. Well-arranged tabular format of the result file allows easily importing it into Microsoft Excel and exploiting its powerful functions to achieve further processing of measured values. Using the program Station, the most time consuming part of calibration is automated. Fig. 2 shows a screen of the program Station during an automated measurement.

IV. Conclusions

Electronic calibration station EKS 05-3, used to calibrate different kinds of electricity meters, is described and its function is briefly explained. It consists of the PEM 6711 digital sampling electricity meter, three dual-channel power amplifiers, a set of voltage and current transformers, an equipment for error evaluation and display, a personal computer with control and calculation software and the K2006 precise three-phase comparator. The developed calibration software named Station for the calibration of the designed and constructed PEM 6711 digital sampling electricity meter is also described.

Acknowledgements

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[9] http://www.labgruppen.com/media/fP2200_UserMan_v09.pdf.