UDC 004.424+53.087.7

A.I. Ivon, V.F. Istushkin, S.V. Savran

WEB APPLICATION FOR MEASUREMENT OF THE AVERAGE AND ACTIVE VOLTAGE OF SIGNALS WITH ARBITRARY SHAPE

Abstract. Web application is described which allows measuring with high accuracy the average voltage and the active voltage of electric signals with arbitrary shape on a basis of the scan data of digital images of the analog oscillograms. At creation of the web application were used the software tools for client web applications: HTML5, CSS3, JavaScript and jQuery library. The relative error in determining voltages does not exceed ±2%. The application can be used on the sites dedicated to the digital measuring technique.
Keywords: web application, digital image, oscillogram, average and active voltage.

Formulation of the problem. The raster (digital) images of analog oscillograms of electrical signals are visual experimental data presented in the digital form. This allows using them for measure the parameters of signals with accuracy of digital measuring devices [1]. The carriers of information in digital images are points – pixels, which have coordinates and a color representing by means of RGB code usually.

Digital images of analog oscillograms can be obtained by photographing them with a digital camera from an analog oscilloscope screen. The resulting graphic files can be downloaded to a computer for processing. Such processing requires the creation of special software. For this purpose can be used the base software tools are used for presentation of information in the Internet. HTML and CSS languages allow creating a convenient program interface. JavaScript allows creating an application to scan a bitmap and get the necessary information based on the scan data.

The applied web applications for processing of experimental data can be used on sites of the Internet with scientific orientation. The universality of such Internet sites can be ensured by placing on them not only the informational web-applications, but also the applied web-applications. In this case, the user gets opportunity to process his experimental data using the applied web applications placed on the Internet.

Purpose of the research. The purpose of this work is creation an applied web application for measuring the average and active voltage of electrical signals having an arbitrary shape by means of digital images of analog oscillograms.

It should be noted that to obtain information about the parameters of objects of digital image, it is necessary to have information about the scales of such image. In the case of digital images of analog oscillograms, to determine the values of the time intervals Δt and the instantaneous voltage $U(t)$, information is needed on voltage scale M_U and the time scale M_t. For determine M_U and M_t one can be used the calibration signals or dividing of the oscilloscope scale grid with known values of the calibration voltage U_C and of the calibration interval T_C. If at the scan of the ends of calibration intervals were obtained the coordinates in pixels (x_{1UC}, y_{1UC}; x_{2UC}, y_{2UC}) and (x_{1TC}, y_{1TC}; x_{2TC}, y_{2TC}), respectively, for voltage and time then can be calculated the values of M_U and M_t as:

$$M_U = \frac{U_C}{\sqrt{(x_{1UC} - x_{2UC})^2 + (y_{1UC} - y_{2UC})^2}}; M_t = \frac{T_C}{\sqrt{(x_{1TC} - x_{2TC})^2 + (y_{1TC} - y_{2TC})^2}}. \quad (1)$$

The resolution of the bitmap image in pixels determines the degree of its discretization (quantization). The values of scales M_U and M_t are showing how many units of voltage and time correspond to one pixel. Thus they determine the absolute errors of voltage and time measurement, associated with quantization of digilal image. Obviously, for the digital images with higher resolution these errors are smaller.

When for measuring of the instantaneous voltage of signal $U(t)$ is used a raster image of analog oscillogram, the scan must be performed in two points with the same values of the x coordinate. One point with coordinate y_0 lies on the zero-voltage line of oscillogram, other point with the coordinate y lies on the line of signal. Therefore, $U(t)$ taking into account M_U is defined as:

$$U(t) = M_U(y_0 - y). \quad (2)$$

If we take into account the absolute error associated with quantization of the raster image, then for the instantaneous voltage of the alternating signal $U(t)$ can be obtained the following expression:

$$U(t) = M_U(y_0 - y) \pm M_U\Delta, \quad (3)$$

where $\Delta = 1$ pixel.

It should be noted that at measurement of the instantaneous voltage $U(t)$ by the digital image of analog oscillogram, the blurring of lines in oscillogram gives an additional error. This error can be reduced by focusing of the electron beam in analog oscilloscopes. The scan point must be selected in the middle of the lines of oscil-

logram. In this case the absolute error of the choice of a scan point is about ±1 pixel. Therefore, the absolute error in (3) can be increase in two times:

$$U(t) = M_U(y_0 - y) \pm 2M_U\Delta. \quad (4)$$

As is known [2], the average voltage U_{av} and the active voltage U_{rms} for signals with arbitrary shape are determined in the time interval T according to the formulas:

$$U_{av} = \frac{1}{T}\int_0^T U(t)dt\,; \quad (5)$$

$$U_{rms} = \sqrt{\frac{1}{T}\int_0^T U(t)^2 dt}\,. \quad (6)$$

In the case of periodic electrical signals, the value of time interval T is equal to the signal period. In the case of single pulses this value is equal to the pulse duration.

For measurement the values of U_{av} and U_{rms} it is necessary to scan in the time interval T the line of signal and the y_0 coordinate of the zero voltage line of oscillogram. In the case of sinusoidal signals the y_0 coordinate can be found by scanning in the points corresponding to the peaks of positive and negative half-wave of sinusoid. If the coordinates of these points are (x_1, y_1) and (x_2, y_2), then value of the y_0 coordinate is defined as:

$$y_0 = (y_1 + y_2)/2. \quad (7)$$

From the scan data, integrals in the formulas (5), (6) can be found using the trapezium method, for example. If at scanning in the time interval T of a signal line of oscillogram were obtained an arrays of points coordinates in pixels (x_i, y_i) $1 \le i \le N$, then formula (5) taking in account (4) can be represented as:

$$U_{av} = \frac{M_U}{2(x_1 - x_N)}\sum_{i=1}^{N-1}(2y_0 - y_i - y_{i+1})(x_i - x_{i+1}) \pm 2M_U\Delta\,. \quad (8)$$

Taking into account (4) and neglecting in (6) second degree of the quantization error Δ, the following expression can be obtained for the active voltage:

$$U_{rms} = M_U\sqrt{\frac{\sum_{i=1}^{N-1}(x_i - x_{i+1})((y_0 - y_i)^2 + (y_0 - y_{i+1})^2 \pm\Delta(2y_0 - y_i - y_{i+1}))}{2(x_1 - x_N)}}\,. \quad (9)$$

From equations (8) and (9) it follows that for determine the average voltage U_{av} and the active voltage U_{rms} of signals, the scale of time M_t is not required. Only the voltage scale M_U and the scan data in pixels are required.

From the equation (8) it follows that the value of U_{av} in the time interval T can be calculated with absolute error $\Delta U_{av} = \pm 2M_U\Delta$ by the formula:

$$U_{av} = \frac{M_U}{2(x_1 - x_N)} \sum_{i=1}^{N-1} (2y_0 - y_i - y_{i+1})(x_i - x_{i+1}). \quad (10)$$

Using the formulas (9) and (10) it can be shown that the expression for calculation of the active voltage U_{rms} has view:

$$U_{rms} = M_U \sqrt{\frac{\sum_{i=1}^{N-1} (x_i - x_{i+1})((y_0 - y_i)^2 + (y_0 - y_{i+1})^2)}{2(x_1 - x_N)}}. \quad (11)$$

In this case the absolute error ΔU_{rms} is determined by the expression:

$$\Delta U_{rms} = \pm 2\Delta M_U \frac{U_{av}}{U_{rms}}. \quad (12)$$

Applied web application for measurement of the average voltage and the active voltage of signals by means of a digital image of analog oscillograms should include the following processing steps: 1). Load of image into the browser window; 2). Scaling of image; 3). Determining the coordinate of the zero voltage line y_0 of oscillogram; 4). Scan of the signal line of oscillogram; 5). Calculation on the basis of scan data the values of U_{av}, U_{rms} and signal amplitude A; 6). Output of results.

Fig. 1 shows the web page of application at the final stage of its performance. On the left side of web page there is a table for displaying the data obtained at scan of the digital image. Scanning is performed by pressing the left mouse key in the image point selected by cursor. The coordinates of points are recorded to a table and to the arrays of script, when the event of "*mouseup*" takes place. The table has "Delete row" button, which allows deleting last row of the table for correcting its contents by means of rescan.

The blocks for various processing steps of the web application are embedded in the "Toolbox" block which is located on the right side of web page (Fig. 1). Those are the blocks: downloading of a digital image; scaling; definition of zero voltage line of oscillogram y_0; calculating and outputting of U_{av}, U_{rms}, and A. The scripts embedded in HTML document are implemented by means of the jQuery library. They provide the display of blocks in accordance with the sequence of stages in the processing of digital images of analog oscillograms. For this purpose, the functions *show()* and *hide()* of the jQuery library are used. Each processing block has the set of buttons and form fields for input-output data. At pressing of buttons begin to work script for given step of processing and *alert()* method opens a window with user instruction. To load of images, the properties and methods of FileReader object are used.

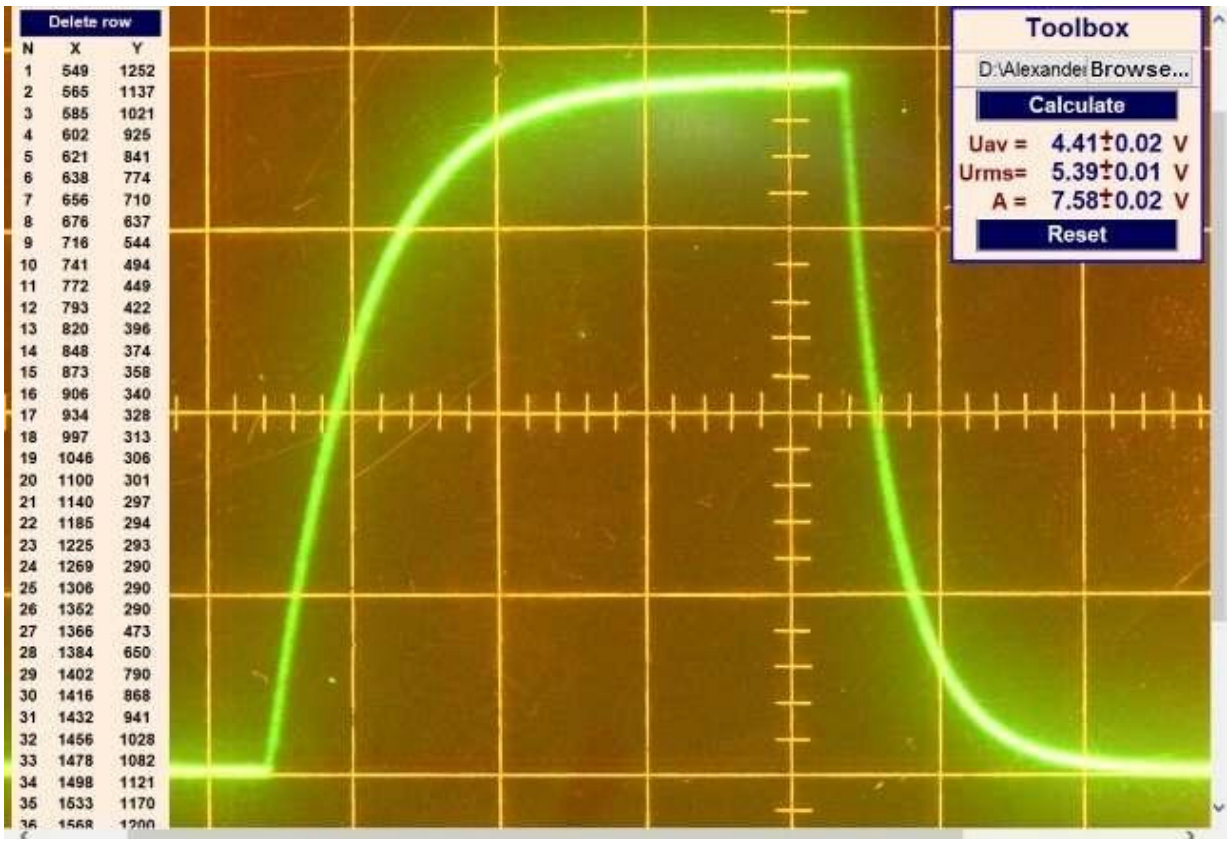

Figure 1 - Web page at the final stage of processing of digital image of analog oscillogram

Conclusions. Applied web application for measurement of the average voltage and the active voltage of signals by processing of digital images of analog oscillograms was created by means of HTML5, CSS3, JavaScript and the jQuery library. The relative error in measurement of the voltage does not exceed ±2%. The application can be used on sites dedicated to the digital measuring technique.

REFERENCES

1. Ivon A.I. Digitization of oscillograms by raster images for rising of accuracy at signal parameters determination / A.I. Ivon, V.F. Istushkin // System technologies – 2017. №1(108). p. 37–40.

2. Бессонов Л.А. Теоретические основы электротехники. Электрические цепи / Лев Алексеевич Бессонов – М: Высшая школа, 1996. – 638 с.

REFERENCES

1. Ivon A.I. Digitization of oscillograms by raster images for rising of accuracy at signal parameters determination / A.I. Ivon, V.F. Istushkin // System technologies – 2017. №1(108). p. 37–40.

2. Bessonov L.A. Teoreticheskie osnovyi elektrotehniki. Elektricheskie tsepi / Lev Alekseevich Bessonov – M: Vyisshaya shkola, 1996. – 638 s.