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Computer System for Measurement of High Voltage Signal during Plasma Process in Solution

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Abstract **-** This paper presents both hardware and software of a system for measurement of high-voltage signal with high resolution. The distinctive feature of the system is its application for investigation of the high-voltage plasma processes in solutions which are characterized by the pulse voltage within the range from 100 V to 3 kV and by the pulse duration from a few to hundreds microseconds. The system is portable and consists of the high-voltage dividers, signal level shift unit, oscilloscope, and computer with software. Structure and main principles of operation are described. Its technical and metrological parameters are given.

I. Introduction

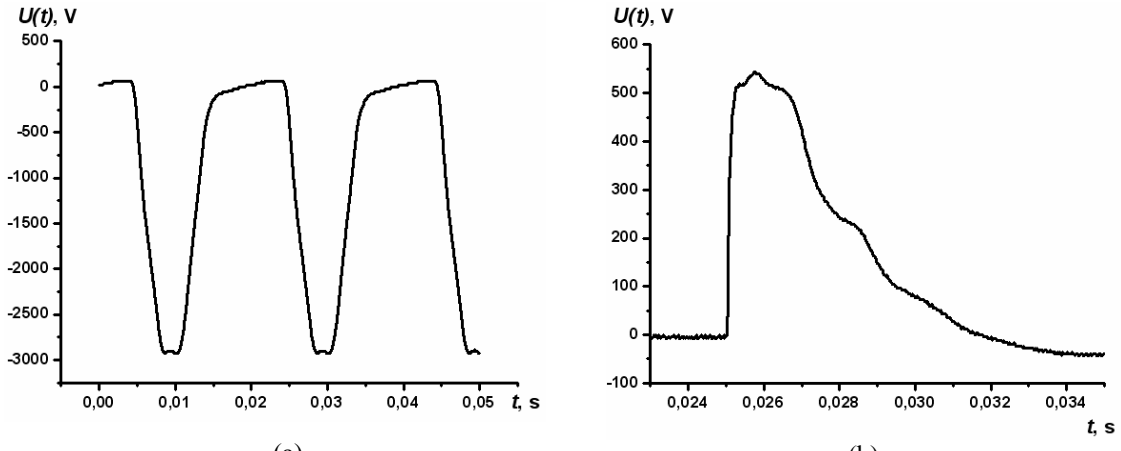
The high-voltage polarization of the two phase boundary causes the plasma processes, accompanying by large density electric current through the boundary. Such processes in the boundary "electrode-solution" are applied to modify metal surfaces providing their necessary anticorrosion, electric and decorative properties [1, 2]. Plasma processes in the boundary of two liquids, for example "water-organic" make it possible to synthesizie new organic materials. The problem of measurement instruments development for investigations of plasma processes is important. In many cases this problem is a key factor for development of physical and chemical models of plasma processes and revealing their new practical applications.

Computer measurement system for investigation of the high-voltage pulse signals of technological plasma processes in solution with the high resolution has been designed by Department of Computer-Aided Measurement Systems and Metrology at Tomsk Polytechnic University. The high resolution of this measurement system helps in finding the informative control parameters of plasma process and in justifying its nature.

II. Measurement technique of high voltage

Technical parameters of measuring instrument developed were determined by parameters of the pulse voltage in various plasma processes.

Voltage signal during plasma electrolytic oxidation process and during plasma processes in the boundary of two liquids are shown in Figures 1 and 2 respectively.



(a) (b)

Figure 1. Voltage signal for plasma process in liquid-liquid boundary (a) and for plasma electrolytic oxidation process (b)

It is evident from the Figures that the signal is a high-voltage pulse of amplitude up to 3 kV, pulse rise-time and

pulse falling-time are more then 60 μs.

The high-voltage measurement technique with high resolution by computer system is based on investigation of one part $U_{ca}(t)$ of the plasma process signal $U(t)$ (Fig. 2).

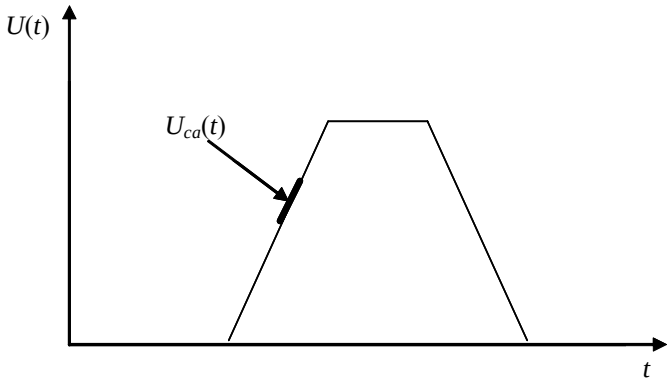


Figure 2. Illustration of the high voltage measurement technique

First, the high-voltage input signal $U(t)$ is reduced to level which is compatible with measuring equipment $U_d(t)$, then signal part is extracted and amplifiered $U_{ca}(t)$ and converted to digit $U_{ca}[n]$ (Fig. 3).

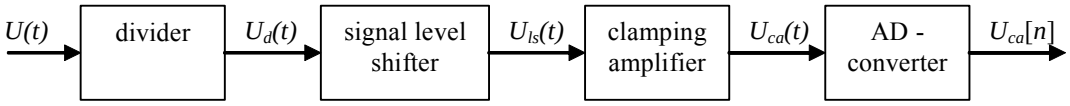


Figure 3. The high voltage measurement technique

For analog-to-digital conversion one can use a digital oscilloscope. In this case the input signal and chosen part of this signal with high resolution can be seen simultaneously at the screen of two-channel oscilloscope. The resolution of measurement system will be determined by resolution of oscilloscope analog-to-digital converter (ADC) and input range of oscilloscope.

Standard oscilloscope maks it possible to analyze signal with small quantization step when it is centered at zero. Therefore, the signal part considerd is shifted by the system to 0 V level and restricted by it preventing oscilloscope from overload [3].

The approach offered belongs to compensation measurement method [4].

III. System structure

The block diagram of computer system is presented in Figure 4. The high-voltage signal $U(t)$ enters the oscilloscope input and signal level shift unit through voltage dividers. As analog-to-digital converter the TDS2024 Tektronix oscilloscope is used. As voltage dividers the 10x and 100 x scope probes are used. The signal level shift unit was designed as device (Fig. 5).

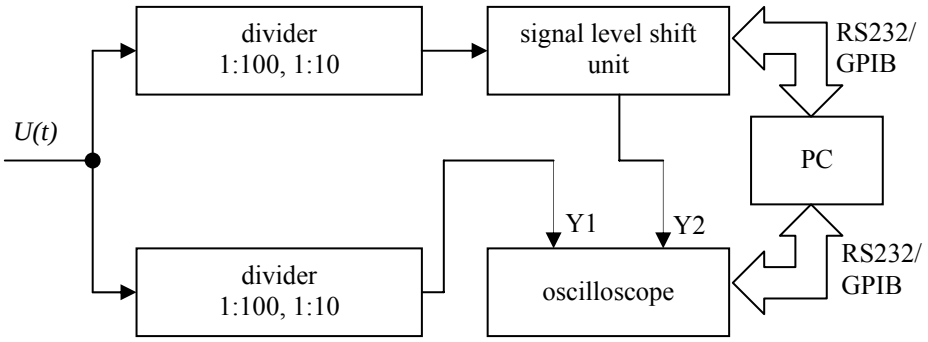


Figure 4. System block diagram

Analysed part of the plasma process is shifted to zero voltage and the target signal is restricted within 0–10 V range by this device. The displaced and restricted signal enters the oscilloscope second input. It results in looking

through different parts of electric signals of plasma process with high resolution of oscilloscope with various displacement voltage.

The displacement voltage from 0 up to 10 V by signal level shift unit with step $\Delta=10V/(2^{16})=153\mu V$ can be set. The measurement resolution is determined by resolution of analog-to-digital converter and digital oscilloscope range. Taking into account the coefficient of the input divider 1:100 and internal coefficient of normalization of signal level shift unit 1:3 and the oscilloscope range 5 mV/div and 8-bit ADC, viewing of input voltage 3 kV with resolution 50 mV can be achieved. Using range 2 mV/div the quantization step can be decreased.

Figure 5. Signal level shift unit

The technical and metrological characteristics of the computer system for measuring electrical parameters of the plasma processes in solutions are as follows:

- range of input voltages from 0 to 3000 V;
- number of measuring channels, 4;
- voltage measuring error, 3%;
- acquisition rates - 2 GS/sec;
- time measuring error 0.6 ns.

The error caused by signal level shift unit is minor in comparison with the oscilloscope one and amounts to 0.5%.

The full investigated signal and part of it are digitized and transferred through serial asynchronous interface bus - RS232 or through parallel interface bus - GPIB. Representation of information as voltage graphs is carried out by the "WaveStar" software delivered with oscilloscope.

An example of measurement for full signal and a part of signal with high resolution is presented in Figure 6.

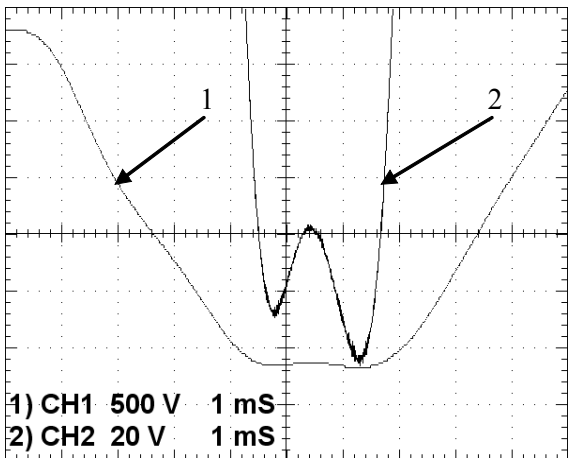


Figure 6. Full signal (1) and part of it (2)

Control of the signal level shift unit is carried out through second RS232 serial asynchronous interface bus of computer using our "Terminal"software. The shift voltage value is input by keyboard.

IV. Conclusion

The computer system developed makes it possible to analyze high voltages signal of plasma processes in solutions up to 3 kV and up to 10^8 V/s slew rate with high resolution.

This measurement system opens new opportunities in investigations of nature and behavior characteristics of high voltage plasma processes in a pulse mode.

References

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