A calibration method is proposed for photogalvanic p-Si sensors for digital x-ray kilovoltmeters operated up to 100 kV, which is based on recording the signals from several p–n junctions in series, simulation of the data by means of integral equations, and recording the x-rays in order to evaluate the calibration curves.

There are digital x-ray voltmeters for equipments operating up to 100 kV [1, 2] which use multicomponent p–Si detectors [3, 4]. In the calibration, one records the signals $F_x$, which are proportional to the residual intensities of the x-rays transformed by the detector when the tube is operated at a voltage $U_0$ and current $I$ at the depth levels $x$ for several p–n junctions in series. The results are normalized to the tube current $I$ for each $U_0$, and $F(x)$ are then used to determine the parameters in the intensity transformation $k = f(F(x))$, which are related to the generation voltages and are used to derive the calibration curve $U_0 = x(k)$. There is a difficulty in selecting parameters uniquely related to the voltages [3, 4].

Our method overcomes this difficulty. Under the same conditions, the normalized data $F(x)$ are fitted by least squares [5] and represented as

$$\{ L(x, F(x)) \mid x \in D(F(x)) \} \subset R^2.$$  

These curves are simulated by integral Fredholm equations of the first kind [6, 7]:

$$F(x) = \int_0^{U_0} K(x, u) F(u) \, du,$$

in which $K(x, u)$ are certain functions of the transforming kernels, $F(u)$ are functions of the energy-flux spectral densities, $U_0$ the maximal energies of the x-rays in the spectrum, and $u$ are the current values.

The equations are regularized and represented in the operational form

$$\alpha \varphi(u) + A \varphi(u) = F(x),$$

and then numerical solutions are derived by algebraic conversion:

$$\varphi(u) = (\alpha E + A)^{-1} F(x),$$

in which $\alpha$ is the regularizing parameter, $A$ an integral operator, and $E$ the unit operator.

The solutions are represented as

$$\{ M(u, \varphi(u)) \mid u \in D(\varphi(u)) \} \subset R^2,$$

in which $\varphi(u)$ are the recovered spectral-density functions for the x-ray energy fluxes.
One distinguishes the energy intervals \( \{ u \in U \mid u_{\text{min}} \leq u \leq u_{\text{max}} \} \), in the regions of definition for these functions, in which they are linear. In those linear ranges, the data are fitted by least squares to \( \varphi = \varphi(u, c_1, c_2) \), in which \( c_1 \) and \( c_2 \) are parameters [5]. The functions are used to derive the calibration constants. For that purpose, they are extrapolated outside the above intervals, and in the new regions of definition one solves

\[
\{ M(u, \varphi(u)) \mid u \in D(\varphi(u)) \} \subset R^2 ;
\{ u \in U \mid u = 0 \}
\]

to find the \( \varphi_0 = \max_{u \in D(\varphi(u))} (\varphi(u)) \) together with the calibration parameters \( k \).

Then, from the solutions to

\[
\{ M(u, \varphi(u)) \mid u \in D(\varphi(u)) \} \subset R^2 ;
\{ \varphi(u) \notin \Phi \mid \varphi(u) = 0 \}
\]

one derives the values of \( u = u_0 \). One assumes that \( u_0 \) is equal to \( U_0 \), the generation voltage for the x-rays.

Least-squares processing gives the calibration curve \( U_0(k) \):

\[
\{ P(k, U_0(k)) \mid k \in D(U_0) \} \subset R^2.
\]