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Uwe Pliquett received the diploma degree in electronic instrumentation and the Dr.-Ing. degree in measurement techniques in 1988 and 1991, respectively, from the Engineering College Mittweida, Germany. From 1993 to 1996 he was postdoctoral fellow at MIT, Cambridge, MA, working on transdermal drug delivery mediated by pulsed electric field. He continued the work on electroporation and bio-impedance measurements in Bielefeld where he received the habilitation in 2000. During 2005 he worked at Old Dominion University in Norfolk, VA, for investigation of changes in biological material due to the application of pulsed electric field. In 2006 he joined the Institut für Bioprozess- und Analysenmesstechnik, Heilbad Heiligenstadt, Germany, where he is currently working on characterization and manipulation of biological material using electrical and optical methods.

Practical application of impedance measurement with minimalistic instrumentation

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Impedance measurement is a non-invasive method for material characterization. On a laboratory scale, very expensive and sometimes bulky devices are common sense. Contrary, for practical applications, very simple solutions are favored, often only with evaluation of the magnitude at a single frequency. Even if handy impedance spectrometers already exist, they are usually still relatively expensive and unsuitable for mass applications or even single use applications. The classic method of impedance measurement is to record the spectrum in the frequency domain, sweeping the frequency range of interest and determining the magnitude and phase at each frequency. Faster methods apply the entire frequency spectrum in the form of a broadband excitation signal (e.g. multisine) and Fourier transform the response signal to obtain the entire spectrum.

Alternatively, the electrical properties can also be determined in the time domain by evaluating the response signal without transformation to the frequency domain. Step functions are particularly advantageous as excitation signals, as they can be simply generated using digital electronics together with easy interpretation of the response as sum of exponential functions. A drawback is the significant data volume that is generated during sampling, especially for simple applications. For example, two million sampling points are required for a frequency range of six orders of magnitude, which is easy to achieve with modern oscilloscopes, but poses a significant hurdle for microcontrollers. A key advantage of exponential functions as response signals is the rapid change at the beginning, which slows down very quickly. This makes it possible to initially sample fast without losing information and then to allow the sampling intervals to become longer and longer. In order not to violate the sampling theorem, integration must take place during the sampling intervals, which is essentially an adaptive anti-aliasing filter. This makes it possible to reduce to just four to ten time instants per decade without losing information content. This method is suitable for implementation in simple microcontrollers. In addition, due to the small data volume, applications for continuous monitoring are suitable. Based on this method, an ASIC was developed that contains a universal front end as well as all the functionality for adaptive integration and sampling. Time domain spectroscopy will be presented both theoretically and using practical examples.