

## Autolab Application Note EC08

# Basic overview of the working principle of a potentiostat/galvanostat (PGSTAT) – Electrochemical cell setup

### Keywords

Potentiostat, galvanostat, PGSTAT, electrochemical cell, reference electrode, counter electrode, working electrode

### Summary

A basic overview of the working principle of a potentiostat/galvanostat is presented. Depending on the application, the connections of the instrument to the electrochemical cell can be (or must be) set up in different ways. Below, the three commonly used electrochemical cell setups are discussed together with the role of the electrodes used in electrochemical measurements.

### Basic principle of a potentiostat/galvanostat (PGSTAT)

A basic diagram of a PGSTAT is presented in Figure 1.

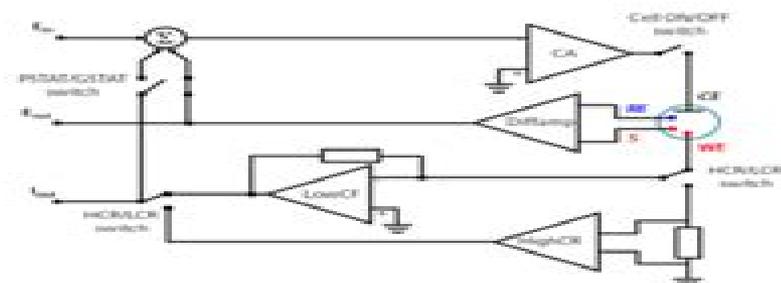


Figure 1 – Basic diagram of a potentiostat/galvanostat

In potentiostatic mode, a potentiostat/galvanostat (PGSTAT) will accurately control the potential of the Counter Electrode (CE) against the Working Electrode (WE) so that the potential difference between the working electrode (WE) and the Reference Electrode (RE) is well defined, and correspond to the value specified by the user. In galvanostatic mode, the current flow between the WE and the CE is controlled. The potential difference between the RE and WE and the current flowing between the CE and WE are continuously monitored. By using a PGSTAT, the

value specified by the user (i.e. applied potential or current) is accurately controlled, anytime during the measurement by using a negative feedback mechanism.

As can be seen from the diagram, the CE is connected to the output of an electronic block which is called Control Amplifier (CA). The control amplifier forces current to flow through the cell. The value of the current is measured using a Current Follower (LowCF) or a Shunt (HighCR), for low and high currents, respectively. The potential difference is measured always between the RE and S with a Differential Amplifier (Diffamp). Depending on the mode the instrument is used (potentiostatic or galvanostatic) the PSTAT/GSTAT switch is set accordingly.

The signal is then fed into the Summation Point ( $\Sigma$ ) which, together with the waveform set by the digital-to-analog converter ( $E_{in}$ ) will be used as an input for the control amplifier.

The cell cables of the Autolab PGSTAT (figure 2) have a total of five connectors: WE, CE, RE, S and ground. The potential is always measured between the RE (blue) and the S (red) and the current is always measured between the WE (red) and CE (black). The ground connector (green) can be used to connect external devices to the same ground of the PGSTAT.

# Basic Overview Of The Working Principle Of A Potentiostat

**C Cleary**



## **Basic Overview Of The Working Principle Of A Potentiostat:**

**Handbook of Nanocomposite Supercapacitor Materials III** Kamal K. Kar, 2021-04-25 This book covers the selection of nanocomposite supercapacitor materials. It describes the most important criteria behind the selection of materials for the electrode, electrolytes, separator, and current collectors, which comprise the key components of supercapacitors for advanced energy storage. It discusses the influence of each material on the unique electrochemical properties of nanocomposite supercapacitors with respect to their energy storage mechanism and stability under extreme and unpredictable conditions. This book is part of the Handbook of Nanocomposite Supercapacitor Materials. Supercapacitors have emerged as promising devices for electrochemical energy storage, playing an important role in energy harvesting for meeting the current demands of increasing global energy consumption. The handbook covers the materials science and engineering of nanocomposite supercapacitors, ranging from their general characteristics and performance to materials selection, design, and construction. Covering both fundamentals and recent developments, this handbook serves a readership encompassing students, professionals, and researchers throughout academia and industry, particularly in the fields of materials chemistry, electrochemistry, and energy storage and conversion. It is ideal as a reference work and primary resource for any introductory, senior level undergraduate, or beginning graduate course covering supercapacitors.

Screen Printing Technology for Energy Devices Andreas Willfahrt, 2019-03-05 The technical application of screen and stencil printing has been state of the art for decades. As part of the subtractive production process of printed circuit boards, for instance, screen and stencil printing play an important role. With the end of the 20th century, another field has opened up with organic electronics. Since then, more and more functional layers have been produced using printing methods. Printed electronics devices offer properties that give almost every freedom to the creativity of product development: Flexibility, low weight, use of non-toxic materials, simple disposal, and an enormous number of units. Due to the production process, these are some of the prominent keywords associated with this field. Screen printing is a widely used process in printed electronics, as this process is very flexible with regard to the materials that can be used. In addition, a minimum resolution of approximately 30  $\mu\text{m}$  is sufficiently high. The ink film thickness, which can be controlled over a wide range, is an extremely important advantage of the process. Depending on the viscosity, layer thicknesses of several hundred nanometres up to several hundred micrometres can be realised. The conversion and storage of energy became an increasingly important topic in recent years. Since regenerative energy sources such as photovoltaics or wind energy often supply energy intermittently, appropriate storage systems must be available. This applies to large installations for the power supply of society, but also in the context of autarkic sensors such as those used in the Internet of Things or domestic industrial automation. A combination of micro energy converters and energy storage devices is an adequate concept for providing energy for such applications. In this thesis, the above-mentioned keywords are addressed, and the feasibility of printed thermoelectric energy converters and supercapacitors as energy storage devices are

investigated The efficiency of thermoelectric generators TEG is low but in industrial environments for example a large amount of unused low temperature heat energy can be found If the production costs of TEGs are low conversion of this unused heat energy can contribute to increasing system efficiency Additionally printing of supercapacitor energy storage devices increases the usability of the TEG It is appropriate to use both components as complementary parts in an energy system Den tekniska tillmpningen av skrm och stencilutskrift har varit toppmoderna i rtionden Som en del av den subtraktiva produktionsprocessen av tryckta kretskort spelar exempelvis skrm och stencilutskrift en viktig roll I slutet av 1900 talet har ett annat fltppnat med organisk elektronik Sedan dess har allt fler funktionella lager producerats med hjlp av tryckmetoder Tryckta elektronikanordningar erbjuder egenskaper som ger nstan all frihet till kreativiteten i produktutvecklingen Flexibilitet l g vikt anvndning av giftfria material enkelt bortskaffande och ett enormt antal enheter p grund av produktionsprocessen rngra av de framtrdande nyckelord som hr till detta omrde Skrmtryck r en allm nt anvnd process i tryckt elektronik eftersom processen r mycket flexibel med avseende p material som kan anvndas Dessutom r en minsta uppl sning p cirka 30 m tillrckligt bra Blckfilmens tjocklek som kan styras ver ett brett omrde r en extremt viktig f rdel med processen Beroende p viskositeten kan skiktjockleken p flera hundra nanometer upp till flera hundra mikrometer realiseras Energikonvertering och lagring har blivit ett allt viktigare mne de senaste ren Eftersom regenerativa energik llor s som fotovoltaik eller vindkraft ofta levererar energi intermittent m ste l mpliga lagringssystem vara tillg ngliga Detta g ller stora installationer f r samh llets str mf rs rjning men ocks inom ramen f r autarkiska sensorer som de som anv nds i saker av saker eller inhemsk industriell automation En kombination av mikroenergiomvandlare och energilagringseenheter r ett l mpligt koncept f r att tillhandah lla energi f r s dana applikationer I denna avhandling behandlas ovan n mnda nyckelord Genomf rbarhet av tryckta termoelektriska energiomvandlare och superkapacitorer som energilagringseenheter unders ks Effektiviteten hos termoelektriska generatorer TEG r l g men i industriella milj er kan exempelvis en stor m ngd oanv nd l g temperatur v rmeenergi hittas Om produktionskostnaderna f r TEG r l ga kan konvertering av denna oanv nda v rmeenergi bidra till kad systemeffektivitet Dessutom kar utskrift av superkapacitorer anv ndbarheten hos TEG Det r l mpligt att anv nda b da komponenterna *Handbook of Nanocomposite Supercapacitor Materials I* Kamal K. Kar,2020-04-16 This book delivers a comprehensive overview of the characteristics of several types of materials that are widely used in the current era of supercapacitors namely architected carbon materials transition metal oxides and conducting polymers It provides readers with a complete introduction to the fundamentals of supercapacitors including the development of new electrolytes and electrodes while highlighting the advantages challenges applications and future of these materials This book is part of the Handbook of Nanocomposite Supercapacitor Materials Supercapacitors have emerged as promising devices for electrochemical energy storage playing an important role in energy harvesting for meeting the current demands of increasing global energy consumption The handbook covers the materials science and engineering of nanocomposite

supercapacitors ranging from their general characteristics and performance to materials selection design and construction Covering both fundamentals and recent developments this handbook serves a readership encompassing students professionals and researchers throughout academia and industry particularly in the fields of materials chemistry electrochemistry and energy storage and conversion It is ideal as a reference work and primary resource for any introductory senior level undergraduate or beginning graduate course covering supercapacitors

*Molecular Electronics: An Introduction To Theory And Experiment* Elke Scheer, Juan Carlos Cuevas, 2010-06-23 This book provides a comprehensive overview of the rapidly developing field of molecular electronics It focuses on our present understanding of the electrical conduction in single molecule circuits and provides a thorough introduction to the experimental techniques and theoretical concepts It will also constitute as the first textbook like introduction to both the experiment and theory of electronic transport through single atoms and molecules In this sense this publication will prove invaluable to both researchers and students interested in the field of nanoelectronics and nanoscience in general Molecular Electronics is self contained and unified in its presentation It may be used as a textbook on nanoelectronics by graduate students and advanced undergraduates studying physics and chemistry In addition included are previously unpublished material that will help researchers gain a deeper understanding into the basic concepts involved in the field of molecular electronics

*Photoelectrochemical Hydrogen Production* Roel van de Krol, Michael Grätzel, 2011-11-09 Photoelectrochemical Hydrogen Production describes the principles and materials challenges for the conversion of sunlight into hydrogen through water splitting at a semiconducting electrode Readers will find an analysis of the solid state properties and materials requirements for semiconducting photo electrodes a detailed description of the semiconductor electrolyte interface in addition to the photo electrochemical PEC cell Experimental techniques to investigate both materials and PEC device performance are outlined followed by an overview of the current state of the art in PEC materials and devices and combinatorial approaches towards the development of new materials Finally the economic and business perspectives of PEC devices are discussed and promising future directions indicated Photoelectrochemical Hydrogen Production is a one stop resource for scientists students and R D practitioners starting in this field providing both the theoretical background as well as useful practical information on photoelectrochemical measurement techniques Experts in the field benefit from the chapters on current state of the art materials devices and future directions

*Photoelectrochemical Generation of Fuels* Anirban Das, Gyandshwar Kumar Rao, Kasinath Ojha, 2022-10-31 Photoelectrochemical processes due to the symbiosis of photochemical and electrochemical processes result in unique reaction pathways and products This technique catalysed by nanomaterials is extensively used to harness sunlight for production of fuels and chemical feedstocks This book explains the basic concepts of photoelectrochemistry as well as their application in the generation of solar fuels from water CO<sub>2</sub> and N<sub>2</sub> as feedstocks It also contains standard methodologies and benchmarks of fuel production including current state of the art in nanocatalysts

as well as their mechanism of action This book Explores fundamentals and real time applications of photoelectrochemistry in fuel generation Reviews basic theory and best known catalysts and best conditions processes for fuel generation in each of the chapters Covers standard methodologies processes and limitations for large scale applications Focusses on sustainable production of fuels from renewable energy and resources This book aims at graduate students researchers in chemical energy and materials engineering

The Journal of the Iron and Steel Institute Iron and Steel Institute,1966 Includes the institute s Proceedings

Proceedings of Asia International Conference on Tribology 2018 Mohd Fadzli Bin Abdollah,2018-09-17 This ebook is a compilation of 234 papers presented at the 6th Asia International Conference on Tribology ASIATRIB2018 Kuching Sarawak Malaysia from 17 to 20 September 2018

**Principles of Electrochemistry** Jiri Koryta,Jiri Dvorak,Ladislav Kavan,1993-04-13 This textbook of electrochemistry assumes a knowledge of basic physical chemistry at the undergraduate level and should benefit the more advanced undergraduate and postgraduate students and research workers specializing in physical chemistry biology materials science and their applications

**Battelle Technical Review** Battelle Memorial Institute,1962

Organic Electrochemistry Henning Lund,Manuel M. Baizer,1991 The editors Lund emeritus organic chemistry Aarhus U Denmark and Hammerich chemistry U of Copenhagen have substantially revised and expanded this basic reference work originally edited by Bazier There are two new chapters on the electrochemistry of C60 compounds and electroenzymatic synthesis and one third of the chapters have been rewritten by new authors these are carbonyl compounds anodic oxidation of oxygen containing compounds anodic oxidation of sulfur and selenium containing compounds electrosynthesis of bioactive materials this replaces natural products and pharmaceuticals organoelemental compounds reductive coupling electrochemical partial fluorination electrogenerated bases industrial electroorganic chemistry and conducting polymers The international group of contributors are all academics in various disciplines in chemistry Annotation copyrighted by Book News Inc Portland OR

**Proceedings of the International Instrumentation Symposium** ,1988

*Corrosion Abstracts* ,1974

**Organic Electrochemistry** Manuel M. Baizer,Henning Lund,1983

*Principles and Practice of Analytical Chemistry* Frederick William Fifield,David Kealey,1976 This book provides a broad base for the study of analytic chemistry by undergraduate and postgraduate students It offers an overview of the principles and practice of analytic chemistry covering topics such as the assessment of analytic data ph complex agents and solubility equilibria separation techniques electrochemical techniques analytic spectrometry radiochemical methods and the role of computers and microprocessors Fifield works for the Centre for Earth and Environmental Research in Kingston Kealey teaches chemistry at the University of Surrey Annotation copyrighted by Book News Inc Portland OR

**Metals and Materials** ,1972

*Green Corrosion Inhibitors* V. S. Sastri,1998-04-22 A book to cover developments in corrosion inhibitors is long overdue This has been addressed by Dr Sastri in a book which presents fundamental aspects of corrosion inhibition historical developments and the industrial applications of inhibitors The book deals with the electrochemical principles and

chemical aspects of corrosion inhibition such as stability of metal complexes the Hammett equation hard and soft acid and base principle quantum chemical aspects and Hansch s model and also with the various surface analysis techniques e g XPS Auger SIMS and Raman spectroscopy that are used in industry for corrosion inhibition The applications of corrosion inhibition are wide ranging Examples given in this book include oil and gas wells petrochemical plants steel reinforced cement water cooling systems and many more The final chapters discuss economic and environmental considerations which are now of prime importance The book is written for researchers in academia and industry practicing corrosion engineers and students of materials science engineering and applied chemistry

*Plating and Surface Finishing* ,1999

*Instrumental Methods of Chemical Analysis* Galen Wood Ewing,1960

**Laboratory Practice** ,1984

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