

52. IWK

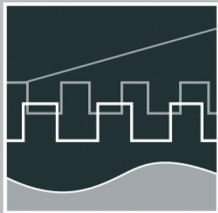
Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium



PROCEEDINGS

| 10 - 13 September 2007

FACULTY OF COMPUTER SCIENCE AND AUTOMATION



COMPUTER SCIENCE MEETS AUTOMATION

VOLUME II

Session 6 - Environmental Systems: Management and Optimisation

**Session 7 - New Methods and Technologies for Medicine and
Biology**

Session 8 - Embedded System Design and Application

Session 9 - Image Processing, Image Analysis and Computer Vision

Session 10 - Mobile Communications

Session 11 - Education in Computer Science and Automation

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen
Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über
<http://dnb.ddb.de> abrufbar.

ISBN 978-3-939473-17-6

Impressum

- Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
- Redaktion: Referat Marketing und Studentische Angelegenheiten
Kongressorganisation
Andrea Schneider
Tel.: +49 3677 69-2520
Fax: +49 3677 69-1743
e-mail: kongressorganisation@tu-ilmenau.de
- Redaktionsschluss: Juli 2007
- Verlag: 
Technische Universität Ilmenau/Universitätsbibliothek
Universitätsverlag Ilmenau
Postfach 10 05 65
98684 Ilmenau
www.tu-ilmenau.de/universitaetsverlag
- Herstellung und
Auslieferung: Verlagshaus Monsenstein und Vannerdat OHG
Am Hawerkamp 31
48155 Münster
www.mv-verlag.de
- Layout Cover: www.cey-x.de
- Bezugsmöglichkeiten: Universitätsbibliothek der TU Ilmenau
Tel.: +49 3677 69-4615
Fax: +49 3677 69-4602

© Technische Universität Ilmenau (Thür.) 2007

Diese Publikationen und alle in ihr enthaltenen Beiträge und Abbildungen sind
urheberrechtlich geschützt. Mit Ausnahme der gesetzlich zugelassenen Fälle ist eine
Verwertung ohne Einwilligung der Redaktion strafbar.

Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.

I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.



Professor Peter Scharff
Rector, TU Ilmenau



Professor Christoph Ament
Head of Organisation

Table of Contents

CONTENTS

	Page
6 Environmental Systems: Management and Optimisation	
T. Bernard, H. Linke, O. Krol A Concept for the long term Optimization of regional Water Supply Systems as a Module of a Decision Support System	3
S. Röhl, S. Hopfgarten, P. Li A groundwater model for the area Darkhan in Kharaa river Th. Bernard, H. Linke, O. Krol basin	11
A. Khatanbaatar Altantuul The need designing integrated urban water management in cities of Mongolia	17
T. Rauschenbach, T. Pfützenreuter, Z. Tong Model based water allocation decision support system for Beijing	23
T. Pfützenreuter, T. Rauschenbach Surface Water Modelling with the Simulation Library ILM-River	29
D. Karimanzira, M. Jacobi Modelling yearly residential water demand using neural networks	35
Th. Westerhoff, B. Scharaw Model based management of the drinking water supply system of city Darkhan in Mongolia	41
N. Buyankhishig, N. Batsukh Pumping well optimi ation in the Shivee-Ovoo coal mine Mongolia	47
S. Holzmüller-Laue, B. Göde, K. Rimane, N. Stoll Data Management for Automated Life Science Applications	51
N. B. Chang, A. Gonzalez A Decision Support System for Sensor Deployment in Water Distribution Systems for Improving the Infrastructure Safety	57
P. Hamolka, I. Vrublevsky, V. Parkoun, V. Sokol New Film Temperature And Moisture Microsensors for Environmental Control Systems	63
N. Buyankhishig, M. Masumoto, M. Aley Parameter estimation of an unconfined aquifer of the Tuul River basin Mongolia	67

M. Jacobi, D. Karimanzira 73
Demand Forecasting of Water Usage based on Kalman Filtering

7 New Methods and Technologies for Medicine and Biology

J. Meier, R. Bock, L. G. Nyúl, G. Michelson 81
Eye Fundus Image Processing System for Automated Glaucoma Classification

L. Hellrung, M. Trost 85
Automatic focus depending on an image processing algorithm for a non mydriatic fundus camera

M. Hamsch, C. H. Igney, M. Vauhkonen 91
A Magnetic Induction Tomography System for Stroke Classification and Diagnosis

T. Neumuth, A. Pretschner, O. Burgert 97
Surgical Workflow Monitoring with Generic Data Interfaces

M. Pfaff, D. Woetzel, D. Driesch, S. Toepfer, R. Huber, D. Pohlers, 103
D. Koczan, H.-J. Thiesen, R. Guthke, R. W. Kinne
Gene Expression Based Classification of Rheumatoid Arthritis and Osteoarthritis Patients using Fuzzy Cluster and Rule Based Method

S. Toepfer, S. Zellmer, D. Driesch, D. Woetzel, R. Guthke, R. Gebhardt, M. Pfaff 107
A 2-Compartment Model of Glutamine and Ammonia Metabolism in Liver Tissue

J. C. Ferreira, A. A. Fernandes, A. D. Santos 113
Modelling and Rapid Prototyping an Innovative Ankle-Foot Orthosis to Correct Children Gait Pathology

H. T. Shandiz, E. Zahedi 119
Noninvasive Method in Diabetic Detection by Analyzing PPG Signals

S. V. Drobot, I. S. Asayenok, E. N. Zacepin, T. F. Sergiyenko, A. I. Svirnovskiy 123
Effects of Mm-Wave Electromagnetic Radiation on Sensitivity of Human Lymphocytes to Ionizing Radiation and Chemical Agents in Vitro

8 Embedded System Design and Application

B. Däne 131
Modeling and Realization of DMA Based Serial Communication for a Multi Processor System

M. Müller, A. Pacholik, W. Fengler Tool Support for Formal System Verification	137
A. Pretschner, J. Alder, Ch. Meissner A Contribution to the Design of Embedded Control Systems	143
R. Ubar, G. Jervan, J. Raik, M. Jenihhin, P. Ellervee Dependability Evaluation in Fault Tolerant Systems with High-Level Decision Diagrams	147
A. Jutmann On LFSR Polynomial Calculation for Test Time Reduction	153
M. Rosenberger, M. J. Schaub, S. C. N. Töpfer, G. Linß Investigation of Efficient Strain Measurement at Smallest Areas Applying the Time to Digital (TDC) Principle	159
9 Image Processing, Image Analysis and Computer Vision	
J. Meyer, R. Espiritu, J. Earthman Virtual Bone Density Measurement for Dental Implants	167
F. Erfurth, W.-D. Schmidt, B. Nyuyki, A. Scheibe, P. Saluz, D. Faßler Spectral Imaging Technology for Microarray Scanners	173
T. Langner, D. Kollhoff Farbbasierte Druckbildinspektion an Rundkörpern	179
C. Lucht, F. Gaßmann, R. Jahn Inline-Fehlerdetektion auf freigeformten, texturierten Oberflächen im Produktionsprozess	185
H.-W. Lahmann, M. Stöckmann Optical Inspection of Cutting Tools by means of 2D- and 3D-Imaging Processing	191
A. Melitzki, G. Stanke, F. Weckend Bestimmung von Raumpositionen durch Kombination von 2D-Bildverarbeitung und Mehrfachlinienlasertriangulation - am Beispiel von PKW-Stabilisatoren	197
F. Boochs, Ch. Raab, R. Schütze, J. Traiser, H. Wirth 3D contour detection by means of a multi camera system	203

M. Brandner Vision-Based Surface Inspection of Aeronautic Parts using Active Stereo	209
H. Lettenbauer, D. Weiss X-ray image acquisition, processing and evaluation for CT-based dimensional metrology	215
K. Sickel, V. Daum, J. Hornegger Shortest Path Search with Constraints on Surface Models of In-the-ear Hearing Aids	221
S. Husung, G. Höhne, C. Weber Efficient Use of Stereoscopic Projection for the Interactive Visualisation of Technical Products and Processes	227
N. Schuster Measurement with subpixel-accuracy: Requirements and reality	233
P. Brückner, S. C. N. Töpfer, M. Correns, J. Schnee Position- and colour-accurate probing of edges in colour images with subpixel resolution	239
E. Sparrer, T. Machleidt, R. Nestler, K.-H. Franke, M. Niebelschütz Deconvolution of atomic force microscopy data in a special measurement mode – methods and practice	245
T. Machleidt, D. Kapusi, T. Langner, K.-H. Franke Application of nonlinear equalization for characterizing AFM tip shape	251
D. Kapusi, T. Machleidt, R. Jahn, K.-H. Franke Measuring large areas by white light interferometry at the nanopositioning and nanomeasuring machine (NPMM)	257
R. Burdick, T. Lorenz, K. Bobey Characteristics of High Power LEDs and one example application in with-light-interferometry	263
T. Koch, K.-H. Franke Aspekte der strukturbasierten Fusion multimodaler Satellitendaten und der Segmentierung fusionierter Bilder	269
T. Riedel, C. Thiel, C. Schmallius A reliable and transferable classification approach towards operational land cover mapping combining optical and SAR data	275
B. Waske, V. Heinzl, M. Braun, G. Menz Classification of SAR and Multispectral Imagery using Support Vector Machines	281

V. Heinzl, J. Franke, G. Menz Assessment of differences in multisensoral remote sensing imageries caused by discrepancies in the relative spectral response functions	287
I. Aksit, K. Bünger, A. Fassbender, D. Frekers, Chr. Götze, J. Kemenas An ultra-fast on-line microscopic optical quality assurance concept for small structures in an environment of man production	293
D. Hofmann, G. Linss Application of Innovative Image Sensors for Quality Control	297
A. Jablonski, K. Kohrt, M. Böhm Automatic quality grading of raw leather hides	303
M. Rosenberger, M. Schellhorn, P. Brückner, G. Linß Uncompressed digital image data transfer for measurement techniques using a two wire signal line	309
R. Blaschek, B. Meffert Feature point matching for stereo image processing using nonlinear filters	315
A. Mitsiukhin, V. Pachynin, E. Petrovskaya Hartley Discrete Transform Image Coding	321
S. Hellbach, B. Lau, J. P. Eggert, E. Körner, H.-M. Groß Multi-Cue Motion Segmentation	327
R. R. Alavi, K. Brieß Image Processing Algorithms for Using a Moon Camera as Secondary Sensor for a Satellite Attitude Control System	333
S. Bauer, T. Döring, F. Meysel, R. Reulke Traffic Surveillance using Video Image Detection Systems	341
M. A-Megeed Salem, B. Meffert Wavelet-based Image Segmentation for Traffic Monitoring Systems	347
E. Einhorn, C. Schröter, H.-J. Böhme, H.-M. Groß A Hybrid Kalman Filter Based Algorithm for Real-time Visual Obstacle Detection	353
U. Knauer, R. Stein, B. Meffert Detection of opened honeybee brood cells at an early stage	359

10 Mobile Communications

K. Ghanem, N. Zamin-Khan, M. A. A. Kalil, A. Mitschele-Thiel Dynamic Reconfiguration for Distributing the Traffic Load in the Mobile Networks	367
N. Z.-Khan, M. A. A. Kalil, K. Ghanem, A. Mitschele-Thiel Generic Autonomic Architecture for Self-Management in Future Heterogeneous Networks	373
N. Z.-Khan, K. Ghanem, St. Leistritz, F. Liers, M. A. A. Kalil, H. Kärst, R. Böringer Network Management of Future Access Networks	379
St. Schmidt, H. Kärst, A. Mitschele-Thiel Towards cost-effective Area-wide Wi-Fi Provisioning	385
A. Yousef, M. A. A. Kalil A New Algorithm for an Efficient Stateful Address Autoconfiguration Protocol in Ad hoc Networks	391
M. A. A. Kalil, N. Zamin-Khan, H. Al-Mahdi, A. Mitschele-Thiel Evaluation and Improvement of Queueing Management Schemes in Multihop Ad hoc Networks	397
M. Ritzmann Scientific visualisation on mobile devices with limited resources	403
R. Brecht, A. Kraus, H. Krömker Entwicklung von Produktionsrichtlinien von Sport-Live-Berichterstattung für Mobile TV Übertragungen	409
N. A. Tam RCS-M: A Rate Control Scheme to Transport Multimedia Traffic over Satellite Links	421
Ch. Kellner, A. Mitschele-Thiel, A. Diab Performance Evaluation of MIFA, HMIP and HAWAII	427
A. Diab, A. Mitschele-Thiel MIFAv6: A Fast and Smooth Mobility Protocol for IPv6	433
A. Diab, A. Mitschele-Thiel CAMP: A New Tool to Analyse Mobility Management Protocols	439

11 Education in Computer Science and Automation

S. Bräunig, H.-U. Seidel Learning Signal and Pattern Recognition with Virtual Instruments	447
St. Lambeck Use of Rapid-Control-Prototyping Methods for the control of a nonlinear MIMO-System	453
R. Pittschellis Automatisierungstechnische Ausbildung an Gymnasien	459
A. Diab, H.-D. Wuttke, K. Henke, A. Mitschele-Thiel, M. Ruhwedel MAeLE: A Metadata-Driven Adaptive e-Learning Environment	465
V. Zöppig, O. Radler, M. Beier, T. Ströhla Modular smart systems for motion control teaching	471
N. Pranke, K. Froitzheim The Media Internet Streaming Toolbox	477
A. Fleischer, R. Andreev, Y. Pavlov, V. Terzieva An Approach to Personalized Learning: A Technique of Estimation of Learners Preferences	485
N. Tsyrelchuk, E. Ruchaevskaia Innovational pedagogical technologies and the Information educational medium in the training of the specialists	491
Ch. Noack, S. Schwintek, Ch. Ament Design of a modular mechanical demonstration system for control engineering lectures	497

Maik Rosenberger, Martin J. Schaub, Susanne C. N. Töpfer, Gerhard Linß

Investigation of efficient strain measurements at smallest areas applying the time to digital (TDC) principle

ABSTRACT

Mechanical stresses can significantly exert a large negative influence on stability, accuracy, maximum allowable forces, operational reliability and durability. Such irregular forces occur also at manual electronic internal and external measuring gauges, for example so-called Quicktester. These measuring instruments are used for fast and precise measurements of inside flutes and inside diameters, as well as for thickness measurements. Through different operation positions and irregular loads, applied on the measuring gauge arm by the user, the measuring arm of the instrument is deformed within the μm range. Thus, the precise determination of the deflection is a decisive advantage for minimising measuring deviations.

The paper at hand presents a novel method for strain measurements exemplified at a Quicktester measuring gauge. The method is based on the application of miniature strain gauges and on the signal analysis with the time to digital principle (TDC). Typically the application of miniature strain gauges is characterised by minimal output signals. In addition the cost criterion and the energy efficiency play an important role for mobile measuring instruments. Thus, an application circuit based on new time to digital (TDC) procedures according to the Picostrain method was developed and successfully applied with miniature strain gauges. The paper presents experimental results regarding temperature characteristic, linearity and resolution. Deflections within the μm range could be stably measured.

INTRODUCTION

Each technical system is subjected to most different environmental conditions and loads during its whole life cycle. In most cases these loads cause mechanical stress within the technical system. Mechanical stress has a negative influence on several properties, e.g. mechanical strength, accuracy and maximal achievable life span.

Up to now it was common to investigate mechanical stresses during the development period and to try to eliminate any influence of them on the system. This implies increased safety factors for the mechanics, oversize of components and increased development and manufacturing costs. In order to minimise these disadvantages it is inevitably important to record data about the mechanical stresses during the whole product life cycle [1]. This applies similarly to large machines as well as to small mechanical measuring instruments such as an electromechanical measuring gauge by the company Kröplin for example. Aim is primarily the reduction of measuring uncertainty for these highly precise manual gauges but also efficient material usage, increased quality and product safety. First tests with strain gauges have been performed by A. C. Ruge in 1938. Thereby, the fundamental of this measurement method was the change of the electrical resistance of metals under strain or under compression [2].

The electromechanical, quick measuring gauges possess a fixed and a movable measuring arm. The movable measuring arm is pressed on the measuring object with a defined spring force. The fixed arm is pressed on the measuring object by the operator. The measuring arm is deformed by several μm due to the contact load. Thus, it is necessary to measure the load of the fixed measuring arm during each measurement. Special challenges for the integration of a suitable measuring unit into such an electromechanical, quick measuring gauge are minimum power consumption, for the measuring gauge is battery powered, and minimum installation place for the measuring sensors and its electronic circuitry.

FUNDAMENTALS OF STRAIN MEASUREMENTS

Measurements of mechanical stress using strain gauges are widely deployed in industrial applications. Typical problems, when applying strain gauges, are nonlinear material properties of the adhesives, temperature drift of the strain gauges itself and irregular behaviour of the material exposed to stress. According to Thomson and Wheatstone the basic resistance of a material is:

$$R_0 = \frac{\rho \cdot l}{A_{\text{cross-section}}} \quad \text{where:} \quad \begin{array}{l} \rho - \text{specific resistance} \\ l - \text{conductor length} \\ A - \text{conductor cross-section.} \end{array} \quad (1)$$

The strain dependent change in resistance R is decisive for measurements with strain gauges, see Eq. 2.

$$R = R_0 \cdot (1 + k \cdot \varepsilon) \quad \text{where:} \quad \begin{array}{l} R_0 - \text{basic resistance} \\ k - \text{strain sensitivity} \\ \varepsilon - \text{change in length (strain)}. \end{array} \quad (2)$$

Aim of the application is the maximisation of the sensitivity of the strain sensitive elements. Thereby R_0 and k are constants. The stress dependent strain ε changes at mechanical loading. As far as constructively possible the strain ε at the measuring area should be maximal. The factor k of metallic strain gauges amounts to 2.05 (constantan). Basically a large factor k is linked to a high sensitivity. However, specifically for semiconductor strain gauges a large factor k also entails an unfavourable temperature characteristic, see [3] page 43. Often deployed measuring analysis methods utilising measuring bridges are detailed in [4].

A new method for the analysis of a strain gauge measuring bridges has been investigated with the help of TDCs, whereby the Picostrain principle was applied. This method was the experimental basis for further investigations. The discharge time of a capacitor is measured with a TDC. The change in discharge time of the capacitor is proportional to the strain [5]. The capacitor is discharged by the resistance of a strain gauge down to an arbitrary switching threshold. The discharge times are compared and the related strains are calculated [6].

PICOSTRAIN TDC TECHNIQUES FOR SMALL STRAIN GAUGES

The experiments and the comparison of different measuring amplifier including an analogue-to-digital converter (ADC) with a measuring amplifier based on the TDC principle have proven, that the ACAM Picostrain system is the best choice. It is an integrated system for the analysis of the strain gauges. It requires no further high-consumption components, such as amplifiers, and is characterised by a low power consumption. A special advantage lies in the fact that no Wheatstone measuring bridge with 4 strain gauges is necessary. Two strain gauges suffice in order to attain maximum accuracy. Tests with four strain gauges did not result in a gain of accuracy. Investigations in suitable miniature strain gauges yielded the strain gauge 1-LY11-3/350 by the company HBM as most suitable [7] (Fig. 1a). This strain gauge has a basic resistance of 350 ohms which is a prerequisite for the application of the TDC

principle. Fig. 1b illustrates a mounted strain gauge on a measuring arm with an active measuring area of app. 4.5 mm². Fig. 1c shows the general measuring setup.



Fig. 1: a) Strain gauge 1-LY11-3/350, b) Measuring area of the strain gauge c) Test setup

Aim of the experiments was the determination of the smallest measurable strain signal. Strains caused by a contact pressure of 3N exerted by the operator amount to up to 42 $\mu\text{m}/\text{m}$ at one measuring arm. Using the Picostrain amplifier enables measuring frequencies of up to 50 kHz [8]. The measuring software of the company ACAM was utilised for the analysis of the measurements at the PC. For the experiments two strain gauges were mounted on the top and bottom side of different measuring arms. Afterwards defined loads were applied (Fig. 2). The maximum load of the measuring arms equals 3 N. Each larger load is an inappropriate operation of the measuring device.

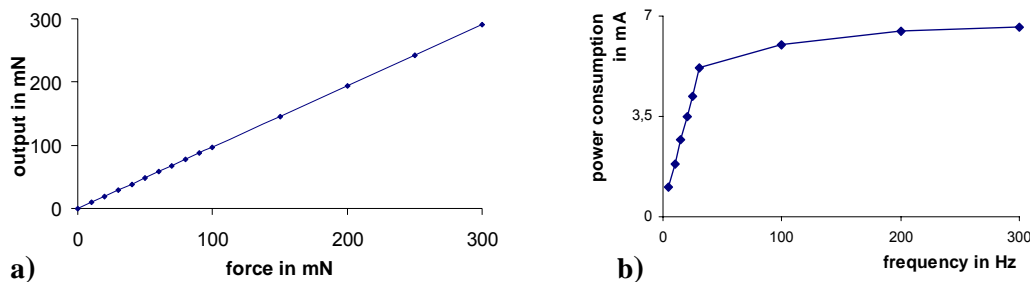


Fig. 2: a) Linearity of the measurement signal b) Power consumption vs. frequency of the TDC circuit

After the experiments investigating the fundamentals the overall system was optimised. The TDC principle offers the opportunity to define most different parameters before starting the measurement. For the integration into a battery powered measuring device an optimal compromise between measuring uncertainty, measuring speed and power consumption had to be identified. A larger measuring frequency is always linked to a larger power consumption (Fig. 2b). A standard delta-sigma-converter which is a special type of an ADC was applied for comparison measurements. In comparison to the TDC method the power consumption of this standard ADC was seven times larger.

Furthermore the TDC principle provides a number of filter functions which had to be adapted for the application at the Quicktester. With the help of test plans an effective resolution of the strain of 15 bits was achieved. Further experiments were focussed on the electrical cable connections between the strain gauges and the TDC Picostrain chip. Thereby screened and firmly fixed coaxial cables turned out to be the best solution.

A stable voltage supply is decisive for enabling the highly precise time measurements with the TDC method. Therefore tests with different voltage supplies like a step-up-controller, a drop-down-controllers and various batteries were performed. The voltage supply based on a drop-down-controller with a battery delivered very good measuring results (Fig. 3a). On contrast the base noise is amplified by factor five when a step-up-controller is utilised (Fig. 3b).

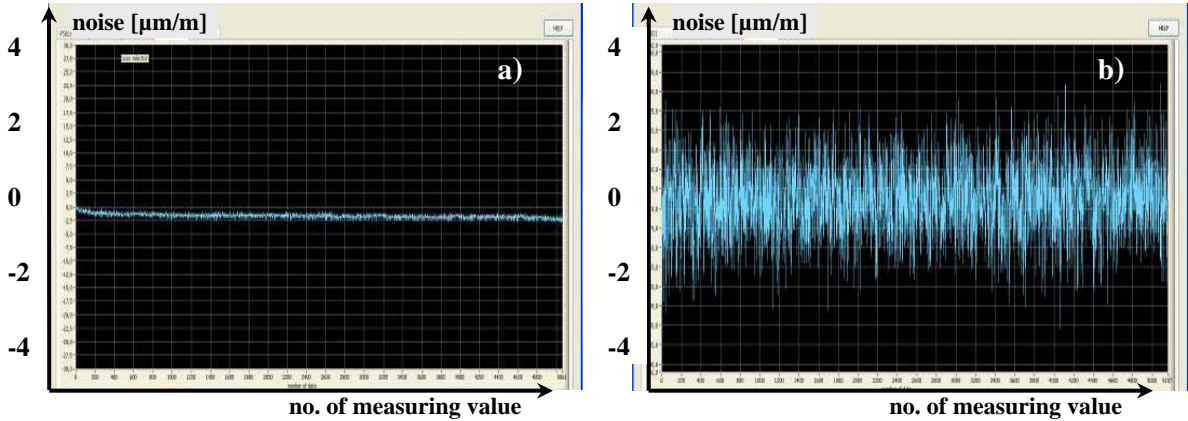


Fig. 3: (a) Base noise of the battery $\pm 0.07 \mu\text{m/m}$ b) Base noise with a step-up-controller $\pm 3.5 \mu\text{m/m}$

EXPERIMENTAL RESULTS

For the integration into Quicktesters by Kröplin an extremely low energy strain measuring system has been developed. The optimal position of miniature strain gauges, namely 1-LY11-350 by the company HBM, on the measuring arms were calculated and tested (Fig. 4a). A strain resolution of $0.14 \mu\text{m/m}$ has been attained with the Picostrain measuring bridge. A minimal power consumption of 5.14 mA at a measuring frequency of 30 Hz poses an ideal compromise between these both parameters. The measuring results prove that the chosen measuring setup is optimal for the integration into Quicktesters. All relevant hard- and software parameters for the integration have been considered. A long battery life span and a high resolution of the measuring arm deformation is enabled.

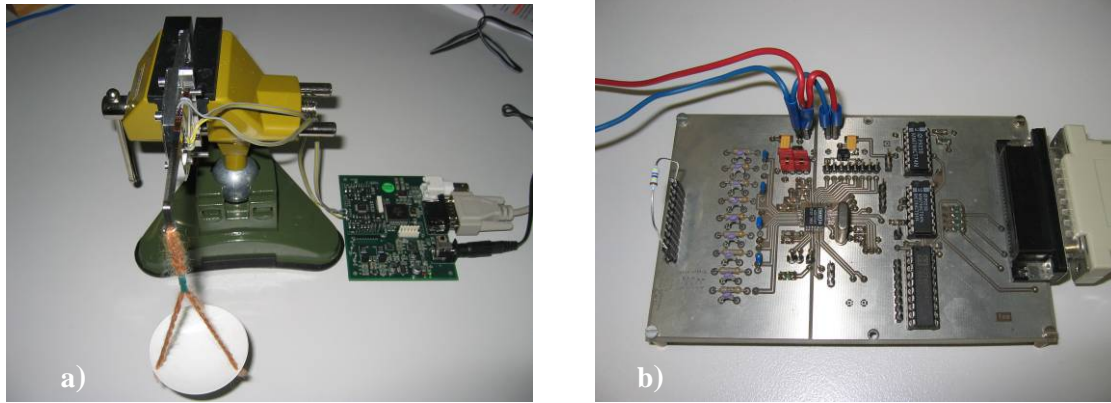


Fig. 4: (a) Test setup for linearity measurements (b) Deployed standard ADC

CONCLUSION

The experiments have proven that the deployment of the TDC principle for strain measurement is ideal for electromechanical measuring gauges such as the Quicktester. This method enables highly precise strain measurements at minimum power consumption. Furthermore the required installation space is minimal and no expensive and high-stable reference voltage supply and no additional measuring amplifiers are required. Comparisons with standard ADC solutions (Fig. 4b) yield the result that these are more cost-intensive and consume more power. When using the TDC principle special care must be put on the cable connection. Finally, the appropriate type of voltage supply (drop-down controller) must be used.

References

- [1] Linß G.: Qualitätsmanagement für Ingenieure. 2. Auflage, Fachbuchverlag Leipzig, 2005.
- [2] Keil S.: Beanspruchungsermittlung mit Dehnungsmessstreifen. CUNEUS Verlag, Zwingenberg a.d. Bergstraße, 1995.
- [3] Hannah R.L., Reed S.E.: Strain Gage Users Handbook. Elsevier Applied Science, Cambridge, 1992.
- [4] Window A.L.: Strain Gauge Technology. Elsevier Applied Science, Essex, 1992.
- [5] Kirianaki N.V., Yurish S.Y., Shpak N.O., Deynega V.P.: Data Acquisition and Signal Processing for Smart Sensors. John Wiley & Sons Ltd, 2002.
- [6] ACAM Messelectronic GmbH: Applikationsschrift 11. Stutensee-Blankenloch, 2004.
- [7] Hoffmann K.: Eine Einführung in die Technik des Messens mit Dehnungsmessstreifen. Hottinger Baldwin Messtechnik GmbH, Darmstadt, 1987.
- [8] ACAM Messelectronic GmbH: Datasheet PS021. Stutensee-Blankenloch, 2006.

Authors:

Dipl.-Ing. Maik Rosenberger, Dipl.-Ing. Martin J. Schaub,
Dipl.-Wirtsch.-Ing. Susanne C.N. Töpfer, Univ.-Prof. Dr.-Ing. habil. Gerhard Linß

Technische Universität Ilmenau
Quality Assurance Department
P.O. Box 100 565
98684 Ilmenau, Germany
Phone: +49 3677 693941
Fax: +49 3677 693823
Email: maik.rosenberger@tu-ilmenau.de