Signals, Processes, and Systems
• If you want to build a ship, don't round up people to procure wood, don't allocate the different tasks and jobs, but arouse their longing for the open sea which stretches to infinity!
   (Antoine de Saint-Exupery)

• The success of language in conveying information is vastly overrated, especially in learned circles. Not only is language highly elliptical, but also nothing can supply the defect of first-hand experience of types cognate to the things explicitly mentioned. .... First-hand knowledge is the ultimate basis of intellectual life. .... The second-handedness of learned world is the secret of its mediocrity. It is tame because it never has been scared by facts.
   (Alfred North Whitehead)

• People ought to be ashamed who take the miracles of science and technology for granted without understanding more about them than a cow does about the botanical principles behind the plants it happily munches.
   (Albert Einstein at the Berlin Funkausstellung – telecommunications exhibition – in 1930)

• Real problems ignore the fact that education has been arbitrarily divided into different school subjects.
   (the author)

• The purpose of computing is insight, not numbers!
   (R. W. Hamming)

• Information and uncertainty find themselves to be partners.
   (Warren Weaver)
**Preface to the 3rd edition**

The 3rd English edition is to appear five years after the 2nd English edition. In the meantime, the 6 German edition has been published, which serves as the reference for this edition. The 1st international English-language version of this "learning system" has had a good reception worldwide and was awarded the German Educational Software Prize DIGITA 2003. At the end of 2008, the first licensed Chinese edition was published at Tsinghua University Press in Beijing.

Multimedia interactive learning systems in both print and electronic form – that is, books which can be "brought to life" and which make possible learning through research and experimentation – are very much in keeping with the spirit of the times.

The changes compared with the 2nd edition pertain mainly to the following points:

- **DASYLab S** is now integrated in this learning system in Version 11. Incidentally, with 25,000 licenses conferred, DASYLab is one of the most sold configurable software for measurement data acquisition worldwide!

- The essential link to the outside world for the purpose of the acquisition and output of real signals in the S Version is still the soundcard – i.e. the two high precision analog inlets and outlets.

- Again, many of the meanwhile 280 DASYLab experiments have been extended, revised and optimised. Illustrative materials, an essential part of the learning system, have been revised and extended.

- Additional contents have been added: the fundamentals of wavelets in Chapter 3 and the Discrete Wavelet Transformation DWT as the method for the recognition of patterns, compression and noise elimination in Chapter 11. Now Chapter 14 on neural networks and Chapter 15 with the mathematical modelling of signals - processes - systems complete this edition.

As the many written reactions and requests for licences from universities and academies show, this learning system has been received positively, indeed enthusiastically. The idea of being able to conduct exciting experiments on a (home) computer, without the material equipment of expensive laboratories, appears to have caught on.

I must again thank the DASYLab team from National Instruments in Aachen, the measX company and the team at the Springer publishing company. All have worked together superbly with me and were always open to my special wishes! A special thanks to Dr. Joachim Neher from the Fraunhofer Institut IPA in Stuttgart. The modules for neural networks developed by him have been modified for my purposes and supplemented, so that I could realize my educational concept. His best gift to me was the new 3D-FOURIER-module.

A learning system of this kind grows, blossoms and flourishes from the interaction between users and the author. For this reason I am always happy to take up any concrete suggestions, which will be given careful consideration and included if possible. I look forward to hearing your ideas.

Düsseldorf, January, 2013

Ulrich Karrenberg
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Introduction

Education, further education and training in the field of microelectronics/computer and communications technology are currently at the focus of public interest. Highly qualified experts are desperately needed in these areas which have an excellent future market potential. Future-oriented approaches for university and school courses and for home study and exploratory learning are, however, non-existent.

A science that people can understand

When students chose their subjects they generally shun those which involve the theory and the technical aspects of the field of signals – processes – systems. These subjects have a bad reputation because they are regarded as "difficult" and because there are many hurdles to overcome, both with regard to the preparation for a degree course and to the course itself.

Universities and industry have done very little so far to remove these obstacles, although the above-mentioned field is connected with the most important, high-turnover industry and service sector.

As a instructor for teachers, the author was shocked when he found that worldwide there was apparently no convincing basic didactic concept in the field of microelectronics, computer-, communications- and automation technology for those preparing to study these subjects or already attending a university course. He asked himself why university courses overemphasised the theoretical aspects, whereas job training was practice-orientated. He arrived at the conclusion that, particularly in the above-mentioned field, theory and practice must form an integrated whole.

The following anecdote highlights the theory/practice dilemma: 14 trainee teachers are taking part in a seminar on telecommunications/technical informatics. All of them are engineers with university diplomas, some of them even have practical job experience. One of them is faced with the problem of having to conduct a sequence of lessons on control engineering at a vocational school. Consequently, the agenda of the seminar is changed to "didactic reduction and elementarisation". All the trainee teachers attending took part in lectures, seminars and practicals on control engineering as a part of their degree course. When the trainer asks them if they remember a basic term or concept in control engineering they hesitate and eventually come up with \textit{LAPLACE transformation}. When they are asked what the term is about they have to admit, rather sheepishly, that they can do calculations using the relevant formula, but do not really have any idea about the fundamental background.

It cannot be denied that topics that are taught at universities are largely taken in as mere facts and then applied without reflection and a deeper understanding of the subject matter. But there are alternative ways of teaching topics to improve the efficiency of the learning process and use the time involved economically.

In short: the learning system presented here uses various different methods aimed at

- providing access to the fascinating discipline of Signals – Processes – Systems even for those who have not had any previous scientific experience in this academic field.
• improving the symbiosis of theory and practice while taking a degree course.

• facilitating the transition from university to job life for graduates to avoid a "practice-shock".

This book has an interdisciplinary approach and involves sciences which deal with communication in the widest sense if they are of didactic relevance in the achievement of an objective.

Teaching and learning are *communicative phenomena*. This book considers the findings of recent brain research on visual learning and the development of consciousness (by interaction with the outside world) and the findings of the psychology of learning. Over two hundred high-quality Illustrations and designs for transparencies, simulations and experiments form the core of this learning system.

The subject matter is illustrated and backed up mainly with reference to physics. Electromagnetic oscillations, waves and quantums are information carriers; there is a physical exchange between transmitter and receiver. The technology involved here is defined quite simply as the sensible and responsible application of the laws of nature because in technology – including the field of Signals – Processes – Systems – nothing works unless it is in accord with these laws.

There is a wealth of specialist literature in all languages available using mathematical models to explain phenomena in signalling systems. This approach is also very popular with university lecturers. But instead of adding yet another publication based on this approach, the most important methodological measure in this book is to avoid using mathematical models. This methodological approach aims at removing obstacles for learners and facilitating access to this discipline.

This learning system thus complements in an ideal way the materials used by university lecturers. In addition, it caters for the vast number of people for whom access to this discipline has been very difficult.

**Target groups**

The above exposition has already given you an idea as to who the target groups of this book are:

• University lecturers
  
  • who want to use high-quality visual material, interactive simulations and graphic explanations of signalling processes for their lectures and seminars.
  
  • who want to visualise the role mathematics plays in signalling systems when they talk about mathematical models in their lectures.
  
  • who appreciate being able to design and undertake laboratory experiments and exercises almost free of charge, or have them designed by students at their PCs.

• Students of engineering sciences at technical colleges and universities such as microelectronics, technical informatics, control-, measuring- and automation technology, information- and communications technology etc. who feel that they have lost track of the basic content of their course in the "mathematical jungle" of lectures on systems theory.
• Students of other technical or scientific disciplines who have to deal with computer-assisted processing, analysis and representation of measuring data (signals) but who wish to avoid mathematical and programming barriers.

• Student teachers in the above disciplines whose problem consists in translating the "theory of signals – processes – systems which is mainly formulated in mathematical terms into language consonant with the imaginative potential of school children. (simplifying and presenting in an elementary way in accordance with educational method).

• Teachers of the above-mentioned disciplines at vocational schools and colleges who are looking for up-to-date approaches and teaching materials which they wish to use in their teaching.

• Engineers in a given profession, whose university training took place some time ago and who as a result of deficits in maths and information science (programming languages, algorithms) have not been able up to now to deal with modern aspects of computer-based signal processing.

• Skilled workers and technicians in the above disciplines and professions who would like to qualify further in their profession by home study.

• Physics teachers at the secondary level who would like to demonstrate the importance of their subject for understanding modern technologies using the example of the complex "signals – processes – systems" for example, in the framework of an advanced course in "Oscillations and Waves".

• Students in professions related to information technology or in the microelectronics – computer technology – communications technology profession who are undergoing training at vocational schools, vocational colleges and engineering polytechnics.

• Those who are interested in a popular presentation of science in order to obtain a lively overview of this highly topical field.

• Students who have not yet decided on a profession or course of study at a university and who would like to inform themselves about this discipline but who up to now had no access to this field as a result of the mathematical bias.

• Firms which work in the field of measurement, control and automation technology and who are interested in in-house training and further education.

**Graphic programming**

The central idea of this system of learning is the implementation of a professional development environment for the graphic programming of signal processing systems. In accordance with this further obstacles have been removed along with algorithms and programming languages whereby it becomes possible to focus on signal processing itself.

DASYLab working in the background makes real signal processing and simulation possible. The software provides an almost ideal and complete experimental laboratory with all imaginable "equipment" and measuring instruments. DASYLab is distributed by measx GmbH & Co. KG, Germany (licensed by National Instruments Ireland Resources
Limited – a subsidiary of National Instruments in Austin, Texas) in many countries and languages with great success and is used in the field of measurement and automatic control technology. Whereas the individual industrial licence is by no means affordable in the context of training or education programmes this educational system comes with a study version which has the same performance and which is supplied practically free of charge. It is very easy to operate and offers all the possibilities of developing, modifying, optimising, discarding and redesigning one's own systems or applications.

**The digital Edition**

The DVD contains the complete digital version of the book - multimedial and interactive, including all the programmes, videos, manuals etc. The "siprosys.pdf"- file and the book are identical.

**How to install the system**

As a result of the restrictive properties compared to earlier Windows versions, it has become almost impossible to run the file directly from the CD or DVD whilst using "Windows Vista" or "Windows 7". Although, it was never recommended due to time lags which may occur and occasionally slow down the application significantly.

A new installation routine has therefore been created, where the entire learning system is installed on partition C with a single click, including the extensive video files.

Boot your PC. After loading Windows insert the CD into the drive. After a brief moment you will see the following display on your screen:

![Illustration 1: The display after starting the CD](image)

*Here, the "Installation" button was pressed. Then further details of the implementation appear below*
Pressing the according button installs the entire learning system. Acrobat Reader will be needed for the display of the learning system. If not yet installed, the included Version 10 of the Reader will be installed.

**Important notes about DASYLab Version 11**

As mentioned before, DASYLab 11 is a professional program used worldwide in the fields of industrial measure-, control-, adjustment- and automatisation technology. This version runs under the following system software:

- Windows 2000 Update Rollup 1 for Service Pack 4
- Windows XP Pro with Service Pack 3
- Windows Vista 32 bit, with Service Pack 2
- Windows Vista 64 bit (as a 32 bit application)
- Windows 7 ... 32-bit and 64 bit (as a 32 bit application)

For DASYLab S 11, only one interface is of importance for this learning system: the indispensable sound card driver. Except the serial interface all other drivers are restricted.

**Installation of the learning system**

Please click on “installation” now. It will take several minutes to install due to the large data material. First the actual learning system itself is installed, then DASYLab Version 11. You need to press “next” several times and agree to the license conditions by pressing “yes”.

Not until the menu shown in Illustration 2 appears, you click “finish”. Now, the actual installation procedure is finished. If you have already installed Acrobat Reader 10, an according final information appears.

**Illustration 2:** Information at the end of the installation process

**Activating the *.dsb files**

The folder "C:Users\Public\Public Documents\DASYLab S11.0.2\EN\worksheets" now contains about 270 files with the extension "*.dsb". They represent the systems you will have to work with interactively in the "Learning System".
Until now, the user had to decide which program to open the ".dsb" files with. This is no longer necessary with the new installation routine. But if you should have problems of this kind using older Windows versions, create a shortcut of the *.dsb file, as shown in Illustration 3.

Illustration 3:  
**Linking the *.dsb files with DASYLab.exe**

You will not find at once the file Dasylab.exe in the window. Therefore press the button "Select..." and find the file Dasylab.exe in the explorer via the folders "programs" and "dasylab". Click on once and then confirm in the window "open with". Then DASYLab will start and load this file.

After the installation, you will find a shortcut on your desktop for the learning system. Double-click, and the system will start automatically from now on.

Illustration 4:  
**Keyword search**

The installed version of the Acrobat Reader has a very comfortable search function for the digital book. The image shows the handling. Consecutively, all search results are shown, even for images and, as a new feature, the index register.
Illustration 5: Handling the interactive document

The interactive learning system

The file siprosys.pdf is designed as an interactive and multimedia medium. There are active links which lead to other programs or pages of the learning system.

Users are recommended to familiarise themselves with the use of Acrobat Reader. Many things can be grasped and carried out intuitively by experienced users. You will find the (official) manual for Acrobat Reader in the folder Documents if any problems should arise.

The links in the pdf-documents are designed as active surfaces. If they are not specially designated the cursor will inform you. The normal cursor symbol "hand" changes to "index finger" (see Illustration 5).

There are three different links in the learning system:

- Each capital heading on the first page of the chapter is enclosed in a yellow frame. Click on to this surface to start a "screencam" video with an introduction to the relevant chapter. Switch on the loudspeaker of the PC and wait some seconds.

- The major part of the roughly 280 Illustrations in the book are linked to the relevant DASYLab applications which carry out the experiment corresponding to the Illustration. This experiment can be modified or changed at will. The change should be stored and filed under a different name. To return to the pdf-document simply finish DASYLab. If DASYLab remains active in the background no further DASYLab link can be started!

- Pointers to other parts of the document – for instance from the table of contents or other Illustrations – are also linked. To return to the previous part of the document select the relevant arrow key above right in the menu (see Illustration 5).
The best interactive and multimedia use of Acrobat Reader is achieved only after adding additional tools. For example, if you have chosen the zoom function for an image and you were redirected to another location in the document you can easily return by the button "Previous View". Accept the suggestions shown.

Integrating the chapter videos in the learning system

As already mentioned, each chapter has its video in English, introducing you in the topic. Hitherto the file of the video had to be copied “by hand” to partition C. With the new installation routine this happens automatically.

Technical characteristics and requirements

To run the file your computer must reach at least 1 GB of main memory. A full-duplex soundcard with the appropriate driver for your operation system is needed to handle the input- and output singals. The stereo -input and -output of the soundcard results in having two analogue input and output channels where real NF-Signals can be sent or received.

You can look for manuals of dealing with DASYLab and the input and output of real signals via soundcard in the "Documents" folder. The pluggable USB Sound Adapter 7.1 of DeLock should also be mentioned. This adapter contains the whole A/D- and D/A conversion outside the PC, thus not increasing the noise level by the motherboard.

In networked PC systems the learning system should basically be installed local on each PC. So far there is no typical network version available. However, expert users say that it is possible to install the learning system – for instance, in a fast NOVELL network – purely on the server.
System development with block diagrams

DASYLab has a range of modules (components), which each represent a signal process. By synthesizing these modules to form a block diagram a signal system is created.

These modules can be found in the menu headings (for example 'Data reduction'). It is recommended to delete the panel bar on the left of the screen and export each module from the menu. Thereby you gain a better overview just as a larger working surface.

Illustration 7: **Block Diagram (with signal visualization) as signal-technical system**

The video on Chapter 1 shows you how to work with DASYLab. Help in DASYLab and the manuals in the folder "Documents" give you detailed information.

The easiest thing you get to know is the "interaction" of each module by recouring to the numerous examples of the learning system. Trying out yourself might help more than the study of the manuals.

All the examples in the learning system are optimised for the 720p-screen resolution (1280 x 720). Of course a higher resolution can be used as pictures cannot in principle be big enough. However, you will hardly find a beamer with a higher resolution for teaching purposes.

The possibilities of DASYLab of measuring precisely visualised data and measurement results with the cursor are impressive. You can

- enlarge signal segments (zooming),
- measure accurately the visualized data/test results with the cursor,
• use "3D-representations" for the visualisation of large amounts of data ("waterfall" and "frequency-time landscapes", including colour sonograms),

• integrate these vector graphics directly into your documentation (likewise the block diagrams) by just pressing a button.

The simplest possibility of import and export real (analog) signals is provided by an inexpensive headset (headphones plus microphone). This "hardware" is above all practical when students are working together in groups.

Please remember that in this S-Version of DASYLab the processing of real signals by means of the technical features of the sound card is limited. For instance, slow fluctuating signals cannot be inputted via the sound card because it has coupling capacitors at its inputs. The manual, however, gives a circuit for the conversion of the instantaneous value of a (slowly changing) measurement voltage into an (instantaneous) frequency by using a simple voltage-frequency converter (VCO). This is similar to processes in telemetrics.

Illustration 8: 

Layout Presentation

For the presentation of visualised data and the easy handling of the created system the so-called layout presentation is available. It is equivalent to what is usually to be found on the front panel of a measuring instrument which conceals the technology in the casing.

As the aim of this learning system is precisely to convey these systems and the technical background it is not used in this book.

For professional applications – for instance in automation technology – you will require the industrial version of DASYLab and special multifunction and interface boards together with DASYLab drivers.

This DASYLab S-Version contains more (special) modules as the industrial version. For obvious reasons only the data format was changed and the possibilities of communicating with hardware peripherals reduced.