# Visit to Zürich, March 18-22, 1974

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# VISIT TO ZÜRICH. MARCH 18-22, 1974

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Lund Institute of Technology
Division of Automatic Control

# VISIT TO ZÜRICH, March 18 - 22, 1974.

U. Borisson

ABSTRACT.

This report summarizes some impressions from the meeting of heads of control laboratories, March 18, and from the IFAC Conference on Digital Computer Applications to Process Control, March 19 - 22. The company Landis & Gyr was also visited during the stay in Zürich. Karl Johan Åström and Ulf Borisson represented the Division of Automatic Control in Lund.

TABLE OF CONTENTS

MEETING OF HEADS OF CONTROL LABORATORIES.
March 18, 1974.

Karl-Johan Åström and I attended the annual meeting of the heads of control laboratories in Western Europe, which was arranged in connection with the 4th IFAC Conference on Digital Computer Applications to Process Control in Zürich. The topics of the meeting were

- Catalogue of laboratory control equipment.
- Exchange of computer programs between control laboratories.
- Textbooks for education in automatic control and measurement techniques.
- Education and research in automatic control in Switzerland.

A list of participants is given in Appendix I. The next three meetings will be

in 1975 - Rome
in 1976 - Lund
in 1977 - Barcelona

The following subjects had been selected for discussions:

- The role of stochastic processes in control education.
- Practically oriented studies as a means of achieving doctoral degree.
- Applications of modern educational principles.

However, the discussions had to be adjourned until the next meeting due to the limited time available.

Catalogue of Laboratory Control Equipment.

The catalogue of Laboratory Control Equipment [1] had now been completed and it was distributed at the meeting. It had been collected and edited by the Electric Power Engineering Department in Denmark. Commercial equipments are not included. Printing costs for future editions will be shared by all the countries. The name of the designer of a described equipment is generally given. This person can be contacted if further information is required. Once a year supplements will be distributed to the holders of the catalogue.

HEADS OF CONTROL LABORATORIES IN WESTERN EUROPE

March 1974

Report from the working group:

SURVEY ON LABORATORY CONTROL EQUIPMENT

at the meeting in Zürich, March 18, 1974

At the last meeting in Helsinki in June 1973 it was decided to organize an interchange of information about Laboratory Control Equipment, and a working group with the following members was established:

| | |
|---|---|
| Belgium: | Professor J.A.Peperstrate |
| Denmark: | Senior Lecturer P.Martin Larsen, chairman |
| England: | Dr. John Billingsley |
| Finland: | Professor A.Niemi |
| France: | Professor L.Pun |
| Germany: | Dr.-Ing. R.Isermann |
| Netherlands: | Ir. H.Feikema |
| Switzerland: | Professor M.Mansour |

Four description prototypes were worked out and 100 copies were distributed to the Control Laboratories in Western Europe through the members of the working group. In as much as no contact persons were elected in Italy and Spain these contries was not asked for contributions in the first round.

Contributions suitable for reproduction were received from 26 laboratories. The material was carefully prepared - a few descriptions were rewritten - and 100 copies were printed.

The catalogue is available at this meeting primarily for the contributing laboratories because it has only been possible to bring 40 copies to Zürich due to the problem of transportation. The laboratories will be registered carefully in order to make it possible to supply them with compementary descriptions each year.

Three of the prototype descriptions should be added to the catalogue: CH 01/01, DK 03/01 and GB 03/01, while D 09/01 allready is included with a new number.
From 5 laboratories was received material not suited directly for reproduction or not in accordance with the goal of the catalogue: To describe laboratory models or equipment for demonstration of control principles. Some of the material in this cathagory was standard experiment instructions for the students or lists of experiments.

As it has been a laborious jub to collect and prepare the catalogue it is hoped that these five laboratories will excuse that their material has been omitted in this first round.

For future contributions it should be stressed, that the descriptions shall be short and clear sufficiently for the reader to judge if the equipment is suited for dublication in his own laboratory. The material shall be originals of high standard (the photographs shall be screened) ready for immidiate reproduction.

Finally all members of the working group and all contributing laboratories are thanked for the fruitful cooperation.

P.Martin Larsen

Exchange of Computer Programs Between Control Laboratories.

The proposal and the questionnaire for the exchange of computer programs had been distributed previously, see Appendix II. The results of the inquiry are given on the next three pages.

Textbooks for Education in Automatic Control and Measurement Techniques.

The results from the distributed questionnaire had been evaluated by Dr. R. Isermann [2].

SWISS FEDERAL INSTITUTE OF
TECHNOLOGY ETH

INSTITUTE OF AUTOMATIC CONTROL AND
INDUSTRIAL ELECTRONICS

Group of Automatic Control (Prof.M.Mansour)

March 1974

# RESULTS OF THE INQUIRY CONCERNING THE EXCHANGE OF COMPUTER PROGRAMS BETWEEN CONTROL LABORATORIES IN WESTERN EUROPE

At the last meeting of the Heads of Control Laboratories in Western Europe on June 1 and 2, 1973, we were asked to make an investigation concerning the possibility of exchange of computer programs between control laboratories. We worked out a proposal for establishing a program information center. Last december we have sent the proposal and a questionnaire to all control laboratories.

Until last Wednesday (March 13,1974) 34 filled up questionnaires were sent back to us. In the following a summary of the results of the evaluation of these questionnaires is given. Notice that not all remarks which were made on the questionnaires are cited.

J.Tödtli

QUESTION 1 and 2:

- Question 1: 34 yes, Ø no
- Question 2: 34 yes, Ø no

Though all the laboratories support the idea to establish a central service which furthers the exchange of computer programs and all laboratories agree with us that this central service should be restricted to the collection and distribution of information on available computer programs.

QUESTION 3: (Concerning the amount of information which is collected and distributed and the way in which this is done Cp. Proposal and Questionnaire).

- Our proposal: 26 (proposal 1)
- More exact information: 5 (proposal 2)
- Other forms which were suggested:

• " The first proposal as well as the second one. ( Two lab. have suggested this form) (Proposal 3)

• "Your proposal combined with the possibility to obtain upon request from the PIC more exact information as indicated in your second proposal". (Proposal 4)

QUESTION 4: (Suggested modification to proposal 1)

- "We suggest on PROGRAM INFORMATION FORM that the DESCRIPTION is expanded of three lines of 80 characters instead of one, (mod.1) and that the CLASSIFICATION CODE should include 3-4 possibilities for the case of large program systems". (mod.2)
- "Speial classification codes indicating input/output mode (s), e.g. grafic hardware used (and if so, type of device used), (mod.3) availability of program (papertape, magn. tape, cards; binary copy only etc.)...." (mod.4)
- "We think an indication of the test status of the programs should be included in the catalogue". (mod.5)
- From the planned program list it should be clear if these is available:
  - A conveniently arranged program listing (mod.6)
  - An adequate documentation about the program, method used, use of subroutines, description of input-output parameters, capabilities of the program". (mod.7)

FURTHER REMARKS:

Remarks concerning the authors'right

- "It should be pointed out, that added programs are used for research work or teaching only. For industrial or economic application the agreement of the authors should be necessary.

  Furthermore, when the application leeds to publications, reference should be given to the used program except in the cases when the program is standard (e.g. Runge-Kutta-Integrat.)

  Perhaps one should classify the programs according to these and simular restrictions (classes of freedom in application which each author may choose for added programs)".

- "There are many special programs which are developped as part of a research project, a thesis or in cooperation with industry. Although these programs would be the most interesting ones for an exchange we can't see a realization of a free exchange".

- "If a program is used for any paper, the name of the authors of this program must be cited".

- "Most of the programs at Imperial College are covered by a confidentiality agreement. This will normally mean that interested parties will first need to sign a standard letter of confidentially saying that the programs will be used only for research or teaching and that they will not be redistributed to a third party".

- Remark concerning financial arrangement

- "It is not indicated in the proposal how the financial arrangement is to be. This service is interesting only if it can be offered at low or negligible cost".

QUESTION 6: (cp. questionnaire)

- yes: 33

  yes (under some conditions concerning the authors' right):1

Estimated number of programs in the near future: 320

## Education and Research in Automatic Control in Switzerland.

Education in automatic control is given in Zürich and Lausanne.

### ETH, Zürich.

Two departments educate students in automatic control:

Automatic Control (Prof. Mansour) at the Electronics Department.
See page 10.

Remark: The department has the following computers:

| | | |
|---|---|---|
| Digital: | PDP 11-45 | 24 k |
| | PDP 9 | 16 k |
| Analog: | PACE | 50 integrators |
| | | 16 multipliers |

Measurement and Control (Prof. Profos) at the Mechanical Department.
See page 20.

EPF, Lausanne.

Automatic Control (Prof. Roch) at the Mechanical Department.

Prof. Roch is in charge of the automatic control education at five departments in Lausanne. The number of students at EPF in Lausanne is about 25% of the number of students at ETH in Zürich. The division has the following process computers:

IBM 1130
PDP 8
MCS4 (Micro)

Some of the recent research activities are

- Optimal control of electrical power plants (hybrid simulations).
- DDC with micro computers.
- Biological systems. Simulation of the kidney function.

SWISS FEDERAL INSTITUTE OF TECHNOLOGY
(ETH)
INSTITUTE OF AUTOMATIC CONTROL AND
INDUSTRIAL ELECTRONICS
GROUP OF AUTOMATIC CONTROL

March 1974

State Vector

1. List of Members of the Group
2. List of Lectures and Labs
3. List of Current Research Projects
4. List of Publications since last report in 1972

1. LIST OF MEMEBERS OF THE GROUP

Professor: Dr.M.Mansour

Ass.Professor: Dr.W.Schaufelberger

Staff members: Dr.H.Nour Eldin
Prof.Dr.E.Handschin (part time)
PD. Dr.J.Vogel (part time)

Chief Assistant: P.Grepper

+ 11 assistents with research and teaching duties
+ 6 candidates for a doctor's degree.

2. LIST OF LECTURES AND LABS

A new organisation scheme for the Electrical Engineer study has now been introduced, so that many changes resulted for the lectures given by the staff members of the automatic control group.

a) Lectures

1) System- and Communication Techniques 4th + 5th semester
(together with Communication Group) 2+3 hours
Introduction to control theory and to communication techniques - Concepts of the State Space - Systemanalysis - Discrete and Stochastic Signals - Control System Applications - Communication System Applications.

2) Electrotechnique 4th + 5th semester 2+2 hours
(together with Industrial Electronics Group)
(obligatory lecture for the mechanical engineers).
Fundamentale of Electrotechnique.

3) Simulation Techniques 6th semester 3 hours
Introduction to analog digital and hybrid simulation

4) Linear Control Systems 6th semester 4 hours
Continuous linear control systems - Discrete linear control systems - Identification techniques - Sensitivity analysis - Controllability and oberservability.

5) Elements of Digital Computers 7th semester 3 hours

(together with Electronics Group)
Special problems by logical networks - Encoding theory- Computer configuration - Core memory - Arithmetic and control unit - Link system.

6) Fundamentals in Process Computers 7th semester 3 hours

Basic software - Basic hardware - Interface - Peripheral devices - Interrupt systems - Operating systems - Software for direct digital control problems - Some programming considerations.
How to select a computer system - Man Machine Communication.

7) Nonlinear Control Systems 7th semester 3 hours

Analytical methods - Graphical methods - Analog, digital and hybrid computational methods - Second method of Ljapunov - Describing function method - Piecewise linear control systems - Discrete nonlinear control systems - Pulse control systems.

8) Measuring methods and Systems 7th + 8th semester 3 hours

(together with Industrial Electronics Group)
Electrical and nonelectrical measurements - Measurements of transfer-functions - Automated measuring systems - Data conversions - Disturbances - Analysis of stochastic signals - Sensors - Design of measuring systems.

9) Computer Software - Organisation and Design 8th semester

(Computer science group) 3 hours
Introduction to: Input/output channels, Peripheral devices, Programming, Interrupt systems, Programming with interrupt systems, Programmed input/output - Higher level languages - Compilers - Operating systems - Teleprocessing - Computers design.

10) Computer Controlled Systems 8th semster 3 hours

Organisation of computer controlled systems - Methods for direct digital control - Application problems - Multi level-, multi purpos computer controlled systems - Special problems.

11) Optimization of Dynamic Systems 8th semester 2 hours

Parameter optimization - Optimization by calculus of variations - Maximum principle - Dynamic programming - Optimization of digital control systems.

b) Seminar Lectures

Seminar on automatic control 8th + 9th semester

c) Obligatory Lab

Automatic Control Lab 6th semester 6 hours

Analog computation - Electromechanical control systems - Digital systems - Computer controlled systems.

d) Courses in Analog and Hybrid Computation one week

courses in April and October

e) Postgraduate Courses

| | | | |
|---|---|---|---|
| 1) System Theory | 2 semesters | 4+4 | hours |
| 2) Adaptive Control Systems | " | " | " |
| 3) Optimum Control Systems | " | " | " |
| 4) Stochastic Control Systems | " | " | " |

## 3. LIST OF CURRENT RESEARCH PROJECTS

a) Adaptive Systems and Identification

1) Dynamic behaviour and Stability of Adaptive Structures (Prof.Dr.W.Schaufelberger)

2) Determination of System Order and System Identification (PD Dr.H.Nour Eldin)

3) Observability, Controllability and Pole Assignment (PD Dr.H.Nour Eldin)

4) Man-Machine Interface (Dr.A.Altmann)

b) Optimum Control Systems

1) Optimization of the Landing and Take off Manoeuvre for a DC-8 Aircraft (P.Grepper)

2) Effect of Wind Shear and Turbulence on Aircraft Landing (P.Grepper)

3) Optimization of the Path of Satellites (D.Rufer)

c) Nonlinears Oscillations and Stability

Stability of Power Systems (Prof.Dr.M.Mansour)

d) Simulation

Modular, Digital Simulation of Electro/Hydraulic Drives Using CSMP (F.Cellier)

e) On-Line Control

1) On-Line Control of Electrical Machine Systems (Th.Lalive d'Epinay)

2) On-Line Control of Electrical Power Systems (P.Wegmann)

3) Hierarchical System in Traffic Control (J.Tödtli)

4) On-Line Train Control (K.Ebert)

5) Software for On-Line Control (Th.Lalive d'Epinay)

6) Fast Resynchronisation of Turbogenerators with a Digital Computer (P.Wehrli)

7) Weitbereichsregelung der technischen Prozesse mit Gegrenzungen mittels eines Prozessrechners (V.Maletinsky)

## 4. LIST OF PUBLICATIONS SINCE LAST REPORT IN 1972

[1] M.Mansour: Computer control algorithms. Proceedings of JUREMA, Zagreb 1972

[2] M.Mansour: Stability analysis and control of power systems. Elsevier, 1972.

[3] M.Mansour: Oscillations in a class of pulse control systems. Proceedings of the Int.Conference on "Transformations ponctuelles et applications", Toulouse, septembre 1973

[4] W.Schaufelberger: Parameter identification with linear filters. NT Nr.5/1972

[5] W.Schaufelberger: Design of adaptive systems with the direct method of Ljapunov. NT Nr.5/1972

[6] W.Schaufelberger: Adaptive and learning control systems. JUREMA, Int.Symposium on Cybernetics in Modern Science and Society, Zagreb 1973.

[7] H.A.Nour Eldin: An adaptive convex feedback method for linear control systems with quadratic performance index. Preprints of the IFAC World Congress, June 1972, Paris

[8] P.Grepper: Direct identification and optimal control of the landing manoeuvre of an aircraft. Regelungstechnik und Prozess-Datenverarbeitung, H.12/1972

[9] A.Altmann: Application of the line theory to transmembrane potential changes in nerve fibres. Kybernetes, Ed. J.Rose, England

[10] W.Helfenstein: Laser-Interferometer-Measuring system for oscillations with small amplitudes. NT Nr.5/1973

[11] W.Helfenstein / W.Rüegg / W.Willi: Examination of the inner part of the ear using the laser-interferometer method and the Mössbauereffect. Laser und Elektro Optik, Nr.5/1973

[12] W.Rüegg / L.Decrey / W.Helfenstein: Measurments of ultra small oscillations with the Mössbauereffekt. Helv.Phys. Acta, Vol.45/1973

[13] K.Ebert / M.Mansour / H.A.Nour Eldin / D.Rufer / J.Tödtli: Report on the 5th IFAC Congress, Paris, June 1972, NT Nr.11/72

Internal reports and lectures of the staff

[1] M.Mansour: Computer control algorithms, April 1972, Zagreb

[2] M.Mansour: Algorithms for digital control systems. Technical University, Berlin June 1972

[3] M.Mansour: Stability analysis and stabilizing electrical networks. Technical University, Braunschweig June 1972

[4] M.Mansour: Stabilizing electrical networks. University of Nis/Jugoslavia, Sept.1972

[5] M.Mansour: Oscillations in discrete and pulse control systems. University of Nis/Jugoslavia, Sept.1972

[6] M.Mansour: Fundamentals of Systemtheory. Seminar on Cybernetics, ETH Zürich, July 1972

[7] M.Mansour: Stability of power systems. TU Warsawa, Sept.73

[8] M.Mansour: Systemtheory. Lectures at Cairo University, March 1973

[9] W.Schaufelberger: Introduction to optimal control systems. Queen's University, Jan.-March 1972, Kingston/Ontario, Canada

[10] W.Schaufelberger: The hybrid system EAI 580-PDP8e. Queen's University, Aug.1972, Kingston/ontario, Canada

[11] W.Schaufelberger: Adaptive and learning control systems. JUREMA, International Symposium on Cybernetics in Modern Science and Society, Zagreb 1973.

[12] H.A.Nour Eldin: An adaptive convex feedback method for linear control systems with quadratic performance index. June 1972, Paris

[13] H.A.Nour Eldin: Controllability and observability and pole assignment. University of Stuttgart, May 1973

[14] H.A.Nour Eldin: Introduction to numerical solution of systems with distributed parameters. VDI/VDE, Feb.1973, Frankfurt

[15] A.Altmann: Modelling of neuron network. ETH-Zürich, June 73

[16] A.Altmann: Modelling of neuron network. Vortrag an der Neurologischen Klinik der Universität Zürich, June 1973

[17] D.Rufer: The problem of optimal control of two space-crafts, formulated in KS variables. Seminar für angewandte Mathematik der ETH Zürich, June 1972.

[18] A.Altmann: Presentation d'un choix de modèles de neurones. Inst. de Physiologie, Prof.M.Dolivo, Lausanne, Dec.1972

[19] H.A.Nour Eldin: Methods for optimal computer controlled systems. Seminar at ETHZ, July 1972

[20] Th.Lalive d'Epinay: Software organisation for processcomputers. Seminar at ETHZ, February 1974

Dissertations

A.Altmann: Modelling of neuron networks. 1973

IFAC/IFIP 74

# ON-LINE REGELUNG EINER GM- SM-MASCHINENGRUPPE

## Zur Verfügung stehende Versuchseinrichtung

- Digitalrechner PDP-9
- Analogrechner PACE (als DA- und AD-Wandler)
- Maschinengruppe (Schwungmasse, GM, SM und Tachogenerator auf einer Welle)
- 3 Gleichrichterbrücken (1x40A, 2x6A) mit Zündgeräten
- Ankerstromumpoleinrichtung (4 Thyristoren + Steuerelektronik)

## Regelung

Die GM wird konstant fremderregt. Folgende Grössen werden rückgeführt: GM-Ankerstrom, Drehzahl, Phasenspannung vom Netz und von der SM (→ daraus berechnet ein Programm den Positionswinkel $\alpha$). Ein FORTRAN-Programm mit einer Durchlaufzeit von ca. 40 ms berechnet aus diesen Ist-Werten und den Sollwerten die Stellgrösse, die GM-Ankerspannung und gibt dem entsprechenden Zündgerät die erforderliche Steuerspannung. Ist eine Ankerfeldumschaltung nötig, wird sie automatisch vom Programm befohlen.

## Folgende Probleme wurden bearbeitet und werden vorgeführt:

- Drehzahlregelung nach veränderlichem Sollwert in allen vier Quadranten
- Zeitoptimale Synchronisierung zwischen SM- und Netzspannung mit einer Bäng-Bäng Regelung in der Phasenebene. Eine elektrische oder mechanische Belastung der Maschinengruppe wird berücksichtigt
- Regelung nach veränderlichem Positionswinkel der SM-Sinusspannung bezüglich der Netzsinusspannungen.

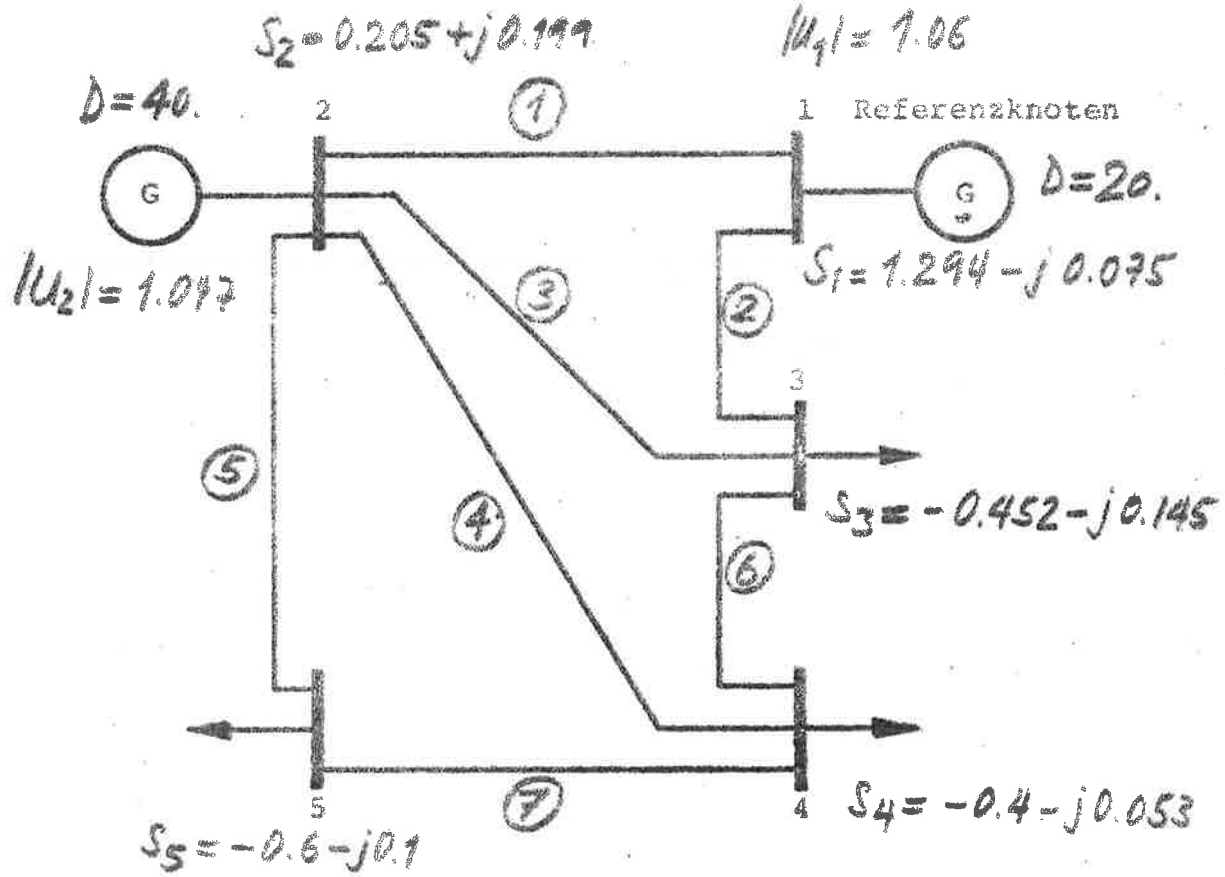
Institute of Automatic Control
Hybrid Laboratry
Swiss Federal Institute of Technology

Zurich, 15.March 1974

# DYNYMIC BEHAVIOUR OF POWER SYSTEMS

A model of anetwork of 5 nodes connected with 7 lines and 3 loads driven by 2 generators is realized on the hybrid computer. Different network faults and load changes are studied. In the present version the turbine/ generator assembly is represented as a system of 5th order, linearized around a working point. Only electromechanical and thermal time constants are considered. The generator is supposed to have a constant voltage back of a transient reactance. The network is reduced to its characteristic P(δ). The initial steady state values are precalculated in a load flow program as well as the coefficients of the network characteristic according to the different fault conditions. During the simulation the digital computer sets the appropriate coefficients at a predetermined time when the according disturbance is meant to take place.

The network and some of its parameters are as follows:




The loads are represented as equivalent impedances, calculated of the initial power consumption and node voltages.
The demonstration shows the changes in power demand, frequency and load angle δ , when different lines are switched on and off and for a change in power consumption. The model is going to be expanded to a mor complex system and will be used for studiing digital control of power systems.

SWISS FEDERAL INSTITUTE
OF TECHNOLOGY
Department of Measurement
and Control

# Survey of Main Activities of the Department of Measurement and Control ETH Zurich

Main activities:

A Education
B Research
C Other activities

## A. Education

1. Education at the undergraduate and graduate level
2. Education at the postgraduate level, doctorate
3. Continuing education

### A.1 Education at undergraduate and graduate levels

- Goal: good fundamental knowledge on measurement and control - ability of applying this knowledge to practical problems - typical example of problem solving by engineers. - No education of specialists

- Educational programme:

  - undergraduate level (compulsory)

    Introduction to measurement and automatic control
    60 h lecture, 20 h exercise and laboratory
    ca. 200 students (mech. engineers, chem. engineers, food prod. engineers)

  - graduate level (optional, one of two subjects for deepened study)

    Automatic control (Analysis and synthesis of control systems)
    90 h lecture, 270 h exercise, design and laboratory
    15...25 students (mech. engineers, physicists)

  - Diploma thesis (Diplomarbeit) on Automatic Control

    5...15 students (mech. engineers)

  - Academic title

    Dipl.Masch.-Ing. ETH. (No special Diploma!)

## A.2 Education on postgraduate level

### A.2.1 Postgraduate studies (Nachdiplom-Studium mit spez.Ausweis)

- Goals: Education of specialists on automatic control and/or interdisciplinary studies

- Educational programme:
  Individually composed programme of lectures, studies, lab.work - thesis
  min. duration: 1 year
  1...2 students

### A.2.2 Doctoral thesis

- Goal: Education of research engineers and scientists

- Educational programme:
  Individually composed; main subject: research project.
  Duration: 2...4 years
  5...10 doctorands

- Academic title:
  Dr. sc. techn.

## A.3 Continuing Education

- Goal: updating of knowledge on measurement and control of engineers in industry etc.

- Educational programme:

  Variable subjects (mainly fundamentals)
  Organisation of 1...3 courses / year
  Duration: 20...30 h / course
  30...100 participants / course

## B. Research

### B.1 General goals:

- Education of young research engineers and scientists for industry and universities.
- Contribution to research on measurement and control in selected fields.

### B.2 Points of main effort:

I Application of advanced theories to practical problems of automatic control

II Process dynamics, modelling, endogenous disturbances

III Dynamical problems of measuring and control components

IV Application of control theory to different problems (e.g.: oscillatory instability in forced flow steam raising systems etc.)

### B.3 Survey of current and recently finished research work:

Most of the research projects mentioned are part of long-term lines of research

I - Design of control systems for large swings
- Design of a predictive $p_H$-control system

former work:
- Optimal excess-air control of large lignite firing systems
- Adaptive PID-control of a heat exchanger system
etc.

II - Dynamics of a cold rolling mill for steel
- Dynamics of special heat exchangers
- Endogenous concentration disturbances due to turbulent mixing

former work:
- Dynamics of spray-type air humidifiers
- Dynamics of other elements of air conditioning systems (rooms, heat exchangers, ducts etc.)
etc.

III - Dynamics of an electrohydraulic step motor
- Problems of pneumatic thickness measuring
- Effects of friction and backlash on transmission of stochastic signals

former work:
- Dynamics of pneumatic signal transmission
etc.

IV - Oscillatory instability in forced flow steam raising systems
- $NO_x$-production in oil burner systems
- Modelling of some microbiological systems (inter-disciplinary research project)

former work:
- Dynamics of steam raising systems

## C. Other activities

C.1 Advising other departments of ETH on measurement and control problems

C.2 Consulting for industry on measurement and control problems

C.3 Expertises

## PUBLICATIONS SINCE LAST REPORT

P. Profos:
Probennahme, ein Engpass auf dem Wege zur Automatisierung analytischer Messungen
Chemische Rundschau

K. Ruhm:
Das Institut für Mess- und Regeltechnik (Reportage)
Chemische Rundschau

P. Profos:
Betrachtungen über Wesen, Ziele und Grenzen der Automatisierung
Revue Technique Luxembourgeoise

P. Profos:
Kap.: Regelung und Automatisierung von Dampfanlagen
Jahrbuch der Dampferzeugertechnik, 2. Ausgabe

P. Profos:
Handbuch der industriellen Messtechnik
Vulkan-Verlag Dr. W. Classen

P. Profos:
Kompendium der Grundlagen der Messtechnik
Vulkan-Verlag Dr. W. Classen

IFAC/IFIP 1974

# VISIT OF THE CONTROL LABORATORIES OF THE SWISS FEDERAL INSTITUTE OF TECHNOLOGY ZURICH

## Program

During the visit the following demonstrations will be presented:

1. Direct Digital Control of a DC-Machine:

   Complex speed and position control of a DC-machine is performed by a digital computer. Any speed and/or position program can be followed with an accuracy of 0.1 °/oo. A powerfull software made it possible for two students to build up and program this experiment.

2. Data-acqusition and Evaluation of Analogue Signals:

   One or more analogue (up to 24) channels can be sampled and stored on magnetic mass storage devices at frequencies up to 50000 samples/second. The data can be examined in an interactive way on a graphic terminal and a set of standard evaluations performed.

3. Hybrid simulation of the dynamic behaviour of power systems:

   The model represents the electromechanical part as a system of 5th order on the analog, the network (assuming steady state) on the digital computer. The model is to be used for the investigation of control algorithms for power systems.

4. On-line identification and adaptive control:

   For investigation purpose of on-line identification algorithmes and adaptive control a small electromechanical system was built with appropriate measure- and control electronic to connect with a process control computer HP 2100.

5. Model of a high bay warehouse:

   The use of an on-line computer for the control and the administration of a warehouse will be shown on a mechanical model. Different control algorithmes for the digital control of DC-motors for moving the crane will be demonstrated.

6. Direct Digital Control of a Thyristor-Controlled Synchronous Machine:

   This experiment shows how speed control of a three phase synchronous machine, alimented by a static converter, can be realized by means of a process control computer PDP-8E.

7. Functional Model of a On-line Computer:

The model consists of a display pannel, driven by an on-line computer. The internal data-transfer of a computer is shown on the display pannel during the execution of an instruction.

8. pH-Control:

A pilot-plant for pH-control of waste water is presented. The non-linear control is realized by a process computer.

9. Turbulent Mixing:

Statistical analysis of turbulent mixing using measurement of salt concentration. The mathematical model developed is based on the theory of turbulence.

10. Non-Linear Modelling:

Based on measurements on a hydraulic torque amplifier a non linear model of the device is developed.

11. Start-up-Control:

The start up of a batch destillation column is demonstrated by using a nonlinear controller designed by an extended constrained control technique.

The demonstration are presented by the following laboratories:

1. to 3.: Hybrid Computing Center (Prof.Mansour)

4. to 7.: Institute of Automatic Control (Prof.Mansour)
(Both from the Faculty of Electrical Engineering)

8. to 11.: Departement of Measurement and Control (Prof.Profos)
(Faculty of Mechanical Engineering)

IFAC CONFERENCE ON DIGITAL COMPUTER APPLICATIONS TO PROCESS CONTROL.

Zürich, March 19 - 22, 1974.

The conference included six survey paper sessions, which were followed by round table discussions, and a large number of technical sessions. Two volumes of proceedings containing the technical papers and a special volume containing the survey papers have been published. Later on the discussion remarks from the conference will be distributed.

Survey Papers.

I visited the following survey paper sessions:

- Digital Computer Applications in Power Systems
  by D. Ernst (FRG)
- Digital Control Algorithms
  by A.P. Sage (USA)
- Software for Process Computers
  by J. Gertler/J. Sedlak (Hungary/CSSR)
- Interface Problems for Process Control
  by T.J. Williams (USA)

Gertler and Sedlak had done a thorough work in summing up the present status of software for process computers. The authors had collected information from all important manufacturers of process computers. The paper by Ernst confirmed that still very little work has been done concerning application of new theoretical developments in control of real power systems. The paper by Sage was hardly directed towards the practical use of different control algorithms and was more a theoretical survey.

Technical Sessions.

I visited the technical sessions in mainly Power Systems and Digital Control Algorithms. The paper by Björn Wittenmark and me, "An industrial application of a self-tuning regulator", was in the latter group. I also attended some sessions concerning chemical industries, e.g. the paper about self-tuning control of a continuous digester by Cegrell and Hedqvist.

POWER SYSTEMS.

Application of Digital Control to Thermal Power Plant for Automation by Fujii et al.

The authors of this paper discuss

- computer control of an automatic start-up and shut-down system,
- a DDC-system,
- an auto-emergency system.

Experiments have been made on a test plant. The steam generator is a supercritical once-through combined circulation boiler, which generates 2 ton steam per hour. The turbine and the electric generator are simulated by an analog computer. The DDC package is built up with standard PID algorithms.

Temperature Raise Control of Super Critical Boiler Using Derivative Digital Filter by Tachivana and Karnei.

The authors have used the same test plant as Fujii et al to study a DDC algorithm for control of the raise of temperature and the pressure of water in the boiler. The temperature derivative is used for the control. Off-line least squares identification with exponential weighting is used to compute the coefficients of the control law (c.f. the self-tuning regulator).

A Direct Digital Control System for a Steam Power Plant by Possenti.

A 23rd order linearized model of a boiler-turbine-generator unit is used in hybrid simulations to study direct digital control of the plant at different operating points. Up to now 20 man years have been used for software development and simulations. The parameters of the investigated optimal regulator are heavily dependent on the operating point of the plant, and future research will concern the use of regulators based on on-line identification.

CHEMICAL INDUSTRIES.

A New Approach to Continuous Digester Control by Cegrell and Hedqvist.

The kappa-number used in pulp-making is a non-linear function of cooking temperature, concentration of active liquor and chip velocity. The purpose of the control is to keep the kappa-number constant by varying the cooking temperature. There are long time delays in the process. The authors use a series expansion to make a certain function of process variables linear in its parameters. An on-line least squares method is used to identify these parameters. The obtained model gives the required set point of the cooking temperature that will give the desired kappa-number. The paper also describes how self tuning regulators are used to keep some other process variables constant, namely the flows of chips and liquor and the chip level.

DIGITAL CONTROL ALGORITHMS.

Comparison and Application of Different DDC-Algorithms for Control of Heat Exchanger by Unbehauen et al.

In this paper some different types of control algorithms are compared. A pilot plant of a high-pressure steam superheater is used for the experiments. The authors discuss different PID regulators, one algorithm based on linear quadratic control theory and one model reference method based on recursive least squares identification. Information about memory requirements and execution times is given, but the results are difficult to compare as some of the algorithms are written in FORTRAN and others in BASIC. In the conclusions the authors consider the regu-

lators of the classical type, e.g. PID, to be among the best ones.

Suboptimum Adaptive Control by Malentinsky and Schaufelberger.

In this paper some algorithms for combined identification and control are discussed. A gradient method and a least squares method with exponential weighting are studied for the identification. The considered process model has no stochastic part and the investigated control law gives a suboptimal solution. Laboratory tests of control of a small DC motor are presented.

Some persons with whom I discussed the self tuning regulator.

J. Rissanen, Linköping. We discussed the problem of finding minimal realizations of regulators for multivariable systems. Concerning a multivariable version of the self tuning regulator it should be possible to use some of the ideas in Rissanen's recent paper "Basis of Invariants for Linear Dynamic Systems" in finding a suitable structure of the desired regulator.

R. Isermann, Stuttgart, said that he and his collaborators are using the self tuning regulator and that they had been surprised at the good convergence properties.

A. Longmuir, Kaiser Aluminium and Chemical Corp., California, was interested in the self tuning regulators and wanted to have our reports. He would like to use the self tuning algorithm in the steel industry.

S. Suh, St. Regis Paper Co., New York, was interested in self tuning control of paper machines. He was involved in the planning of Obbola, the new paper mill near Umeå. He also said that he had some contacts with prof. Brodin in Stockholm.

M. Fjeld, associate professor at the Department of Electrical Engineering, University of Nairobi. Previously he had been with SINTEF in Norway. There he had worked with digital control of paper machines. He was also interested in Sture Lindahls work on power systems control, and he would like to have some of the reports.

T. Wesslen, MoDoCell AB, Örnsköldsvik, was also interested in control of paper machines and he would like to get in closer contact with our division in Lund.

Some General Remarks.

In the field of power systems, computers are still mainly used for data logging, trouble monitoring, alarm point-out, post memory review, etc., and there is not much control. There is an evident trend towards use of decentralized computers. The impression of the discussions concerning interface for process control is dominated by the difficulties of standardization.

Although the topics of this conference concerned applications, there were surprisingly few real industrial applications reported. However, the conference indicated that at least some research centres are making efforts to move new theoretical results into practical use.

LANDIS & GYR.
Visit to Zug, about 30 km from Zürich.
March 20, 1974.

We visited the development department and the environmental control laboratory. The development department works in the following fields:

- Power distribution
- Comfort control
- Industrial process control
  - chemical processes
  - paper, paper coating
  - plastics
  - rubber
  - metal coating
- Big building control

The Billman company in Stockholm now belongs to Landis & Gyr. All research and development is located in Switzerland. In the laboratories micro-computers were tested, and these would probably play an important role for the company in the future.

The environmental control laboratory was newly built. It included a special test chamber. In the laboratory the following functions could be carried out:

- Reproduction of inside spaces with surroundings made of different building materials with arbitrary arrangements of windows, doors, etc.
- Testing of control systems using different methods of heating, ventilation and air conditioning. Varying external conditions of the test chamber can be simulated.

The control and supervision of the test chamber is carried out from a central supervisory panel. The values of 350 measuring points can either be shown digitally or be recorded. The panel also includes a great number of analog regulators. There are no special arrangements for digital data acquisition and processing of the measurements.

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[2] Evaluation of a questionnary on text books used for courses in automatic control and measurement techniques, February 1974, by R. Isermann, University of Stuttgart.

SWISS FEDERAL INSTITUTE
OF TECHNOLOGY
Department of Measurement
and Control

Meeting of Heads of Control Laboratoratories, 18th March 1974, in Zürich

List of Participants

| | | |
|---|---|---|
| Belgium: | Prof. R. Gorez | Université de Louvain |
| | Prof. J. Hoffmann | Université de Bruxelles |
| | Prof.G.van Steenkiste | Université de Bruxelles |
| | Prof.J.Peperstraete | Université de Leuven |
| Denmark: | Prof.O.Jannerup | Copenhagen, DTH |
| | Prof.M.Kümmel | " |
| | Prof.P.M.Larsen | DTH |
| | Prof.L.Trostmann | Copenhagen, DTH |
| England: | Prof.J.F. Coales | University of Cambridge |
| | Prof.F.J.Evans | Queen Mary College, London |
| Finland: | Prof. A. Niemi | Helsinki Univ.of Technology |
| | Prof. P. Uronen | Oulu University |
| France: | Prof.J.L.Abatut | Université de Toulouse |
| | Prof.A.Fossard | ENSAE Toulouse |
| | Prof.Y.Landau | L.A.G.-Grenoble |
| | Prof. R. Mezencev | Université de Nantes |
| | Prof. L. Pun | Université de Bordeaux I |

| | | |
|---|---|---|
| Germany: | Prof.W.A.Gruver | Techn.Hochschule Darmstadt |
| | Prof. R. Isermann | Universität Stuttgart |
| | Prof.Dr.F.Mesch | Universität Karlsruhe |
| | Prof.Dr.R.Quack | Universität Stuttgart |
| | Prof.Dr.G.Schmidt | Universität München |
| | Prof. H. Thoma | Techn.Universität Hannover |
| Italy: | Prof.R.Michelini | Università di Genova |
| | Prof.G.Guardabassi | Politecnico di Milano |
| | Prof. A. Isidori | Università di Roma |
| Netherlands: | Prof.P.van der Grinten | Eindhoven University of Techn. |
| | Prof. F.J. Kylstra | Eindhoven University of Techn. |
| | Prof. H. Kwakernaak | Twente University of Techn. |
| | Prof.H.R.van Nauta Lemke | Delft University of Techn. |
| | Prof. J.E. Rijnsdorp | Twente University of Techn. |
| Spain. | Prof. L. Basanez | Universidad Polit.de Barcelona |
| | Prof. G. Ferrate | " |
| | Prof. R. Huber | " |
| | Prof. J. Pagès | " |
| Sweden: | Prof. U.Borisson | Institute of Techn. Lund |
| | Prof. K.J. Åström | Institute of Techn. Lund |
| | Prof. J. Rissanen | University of Linköping |
| | Prof. B. Quarnstrom | Chalmers University |
| Switzerland: | Prof.Dr.M.Mansour | ETHZ |
| | PD Dr.A.H.Glattfelder | ETHZ |
| | Prof. M. Steiner | ETHZ |
| | Prof. A.A.Roch | EPFL |
| | PD Dr. E. Nour | ETHZ |

PROPOSAL

- A Program Information Center (PIC) is established
- The aim of the PIC is to further the exchange of computer programs between control laboratories in Western Europe. The PIC collects informations on available computer programs and distributes this information periodically to all control laboratories. If somebody is interested in any program on which he has got a first information by PIC, he directly contacts the laboratory where the program was written.
- The collection of information on available computer programs is done as described in the following.
  The PIC sends address forms and program information forms to the control laboratories. Each control laboratory which is in possession of computer programs being useful for other laboratories and which agrees to place them to others disposal will fill in one address form and to each program a program information form. The filled in forms are sent back to the PIC. At any time any number of forms can be asked from the PIC. If the address or the name of the contactman of a control laboratory changes, a new address form has to be sent to the PIC. In the case where a laboratory wants to add a new program, as well as in the case where an earlier announced program has been modified or must be eliminated from the list a program information form should be sent to the PIC.
- The distribution of the collected information is done periodically e.g. every six months. The PIC will send every six months a fully updated list which gives information on all programs presently available (not only the ones arrived during the last 6 months). This list is established by the computer.

The list is divided into two parts, the program list and the address list. Each line of the program list corresponds to one program. Each line consisting of 120 characters contains the information given by the author on the program information form and a reference number given by the PIC. The first four characters of the reference number contain the code referring to the origin of the program. This code can be looked up in the address list.

- The following conventions are suggested:
  Any control laboratory should announce aprogram only if the author principally agrees to place it at other laboratories disposal. In spite of this announicing a program does not obligate the author to renonnce on the preservation of his rights. Any author can always refuse or restrict the use of his programs under certain conditions. For example, the author may wish to oblige the receiver not to give his progra further to any other institute or person.

APPENDICES

ADDRESS FORM

DATE 1. 8. 1976

[ ] NEW

[x] MODIFICATION

ADDRESS OF THE LABORATORY

Fachgruppe fuer Automatik
der Eidg. Techn. Hochschule
Physikstr. 3
CH-8008 Zuerich

NAME OF THE CONTACT MAN AND ADDRESS IF DIFFERENT FROM ABOVE

M. Meier