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## Bibliography Of Power Systems Operator Training Resources

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IEEE Committee Report prepared by the  
PES Working Group on Operator Training (WG78-4)  
Max D. Anderson (Chairman), University of Missouri - Rolla

## ABSTRACT

This paper attempts to provide a current listing of training courses, programs, and resource materials for Power System Operator/Dispatcher training. The training resources are subdivided into five (5) categories:

- I. Dispatcher training courses and facilities developed by the Suppliers/Manufacturers
- II. University Short Courses
- III. Conference Publications
- IV. Reference Books
- V. Correspondence Courses

A brief description of the offerings of each of Suppliers/Manufacturers is included.

## INTRODUCTION

The problems of Power System Operator/Dispatcher Training as we know them today are relatively new. They apply to power systems with modern computer based energy control centers, energy management systems (EMS) and supervisory control and data acquisition (SCADA) systems. Most of the published papers and available training materials have been prepared since 1976. No attempt has been made to include training materials for power plant operators in this paper, though some appear.

The Working Group on Operator Training (WG78-4) has been searching out and collecting training materials for several years. This has been done by surveys of the utilities and the industries that supply the utilities as well as short courses, publications, and reference materials.

The resource material is presented in five (5) categories:

I. Suppliers/Manufacturers - This category consists of training resources designed and fabricated by industry specifically for the electric utilities for

their Dispatcher training needs.

II. Universities - These are short courses offered periodically which are specifically for Dispatcher Training.

III. Conference Publications - These are recent publications currently available. Some of these papers have been prepared by the working group for two (2) COPS sessions and two (2) invited paper sessions presented at the PES Summer & Winter meetings.

IV. Reference Books - These are suggested reference books that are basic to Power Systems Operator Training.

V. Correspondence Courses - These are a sample of courses available by correspondence which can provide the trainee with some background for Dispatcher Training.

The Working Group regrets any omissions that may have been made and notes that they are unintentional. Any omissions are due to (1) failure of the Working Group to be aware of a supplier's training resources or (2) failure of the supplier to respond to the Working Group's request for a brief description of his training resource offerings. Any such omissions should be made known to the Working Group Chairman or contributing authors. It is the Working Group's intentions to update this bibliography periodically as new training resources become available.

Contributing authors include but are not limited to Robert P. Schulte (Bonneville Power Administration), John M. Thorson, Jr. (Control Data Corporation), Don Ewart (General Electric), R. A. Bednarik (Con Edison) and Max D. Anderson (Univ. of Missouri - Rolla).

### I. Suppliers/Manufacturers

Control Data Corporation  
8100 34th Avenue South  
Minneapolis, Minnesota 55440  
612-853-6079

Offer for sale a Dispatcher Training Simulator consisting of a digital computer and a CRT man/machine interface, together with simulation software and data base for simulation training on the utilities premises. The data base can be adapted to represent the utilities network and generation system.

82 SM 336-6 A paper recommended and approved by the IEEE Power System Engineering Committee of the IEEE Power Engineering Society for presentation at the IEEE PES 1982 Summer Meeting, San Francisco, California, July 18-23, 1982. Manuscript submitted February 4, 1982; made available for printing April 14, 1982.

CDC also rents special terminals to access the PLATO Computer Based Education System. Several special instructional courses of interest to dispatchers, substation, power plant and reactor operators and engineers, are available.

CDC has a large number of computer programming, maintenance and operator courses being run continuously. Specialty courses on specific equipment are also available on request. Courses vary from three days to two years.

Power Technologies, Inc.  
P.O. Box 1058  
Schenectady, NY 12301  
518-374-1220

Offers a two volume written text on "Fundamentals of Electric Power Systems for System Operators". The approach used is practical, stressing physical concepts with a minimum of mathematics. The typical educational level expected is high school many years ago with utility experience in non-engineering areas. The goal is to aid the operators in understanding what is happening on the system and why, based on the indications available to them in the control room.

Harris Controls  
P.O. Box 430  
Melbourne, Florida 32901  
305-727-5600

Offers a Dispatcher Training Simulator which operates on the backup facilities of the Harris Microplex 9000 power control center product. It uses the on-line CRT's/Man-Machine Interface, AGC, Interchange Scheduling, Alarm Processing, and SCADA facilities. The trainee is provided with the exact interface used for the on line control. Power System and equipment models are derived from canned scenarios of operational events and a snapshot of the actual on-line system.

HARRIS provides to its Microplex customers a series of courses dealing with computer programming, maintenance and dispatcher training offered year round. Various courses are geared to user levels of a power control center.

General Electric Company  
One River Road  
Schenectady, New York 12345  
518-385-5616

Offers a six week comprehensive Dispatcher Training Course. Intensive classroom instruction is combined with a variety of workshop techniques including demonstrations, experiments, movies, slides and in-class problem solving with the aid of interactive power system simulation.

The course covers: Basic Electricity including mathematical and trigonometric fundamentals applicable. Elements of Electric Power Systems encompassing the characteristics and limits of major pieces of power system equipment. Integrated Power System and Its Control part ties together the isolated system components in a unified power system. Special attention is focused on active, reactive power flow and voltage control. Dynamic Behavior and Control of Interconnected Systems covers study of various system conditions and upsets on the model system with opportunities to assess and correct the upset similar to a real life situation. This part specifically prepares dispatchers to act more knowledgeably and confidently during conditions ranging from normal to emergency situations.

General Electric Company  
BWR Training  
175 Curtner Avenue  
San Jose, California 95125  
408-297-3000

Offer lecture and color videotape instruction to management, engineering and non-plant personnel as well as a variety of courses for BWR plant operators. Classes are given at vendors training center which included a plant simulator.

Stagg Systems, Inc.  
261 Madison Avenue  
New York, New York 10016  
212-697-0616

Specific courses tailored for dispatching and operating engineers are provided in connection with the installation of vendor-supplied computer programs. These are given on the utility's premises.

C-E Power Systems  
Combustion Engineering, Inc.  
1000 Prospect Hill Road  
Windsor, Connecticut 06095  
203-688-1911

Provides on-site classroom-type pre-operational instruction to plant operators and supervisors covering operation of vendor finished equipment. A two week lecture-type program on power plant fundamentals in conjunction with a power plant simulator is also available for a fee. This type of program may be helpful for system operators who do not have power plant experience.

Honeywell  
Process Control Division Training Center  
222 West Peoria Avenue  
Phoenix, Arizona 85029

Offers a variety of lecture-type courses in their training center covering programming, software operation and hardware maintenance for vendor-supplied com-

puter system. Courses last from 1 to 10 weeks. Selected courses may be of interest to system operators having limited exposure to computers.

Babcock & Wilcox  
Power Generation Group  
P.O. Box 1260  
Lynchburg, Virginia 24505  
804-384-5111

Offer lecture-type courses in nuclear plant operation for management, engineering and non-plant operating personnel as well as specialized courses for nuclear plant operators. Classes are given at vendors training center which includes a plant simulator.

Bailey Meter Company  
29801 Euclid Avenue  
Wickliffe, Ohio 44092  
216-943-5500

Offers lecture-type programs covering measurements, measuring devices, analog and digital control concepts and components, computer programming and computer hardware. Some courses also available on videotape. Courses given in vendors training center. Three day seminars covering basics of analog control are given in selected cities.

Resource, Inc.  
Suite 402  
2909 Bay-to-Bay Boulevard  
Tampa, Florida 33609  
813-839-2189

Supplies audiovisual film strips in special cartridges for use on a variety of projectors available through the vendor. Material also available in cassettes. Over 100 films cover a wide variety of topics of interest to shift operators including basics of electricity, power plant systems, distribution systems, customer relations, safety and supervision. Workbooks accompany the films. Films and projectors are for purchase and use on utility premises. Self-contained projectors with built-in screens facilitate use in limited spaces.

## II. Universities

Dispatcher Training Short Courses  
University of Missouri - Columbia  
Columbia, Missouri 65201  
Dr. L. N. Walker  
Electrical Engineering Department  
(314)-882-3510  
Given four times a year - 5 days  
"Power Dispatcher's Short Course"  
Iowa State University  
Ames, Iowa 50011  
Professor J. D. Musil  
Engineering Extension  
(515)-294-4072  
Given annually in May - 5 days

Dispatcher Training Course  
Service Genie Electrique C. P. 165  
Universite Libre de Bruxelles  
Avenue F. D. Roosevelt 50  
1050 Bruxelles, Belge  
Prof. R. Poncelet, Directeur  
(02) 649.00.30 ext 2669

## III. Conference Publications

1. J. M. Thorson, S. R. Greenfield, A. L. Misselt "Uses of Computers in Operator Training", 1981 PES Winter Meeting, Atlanta, Feb. 1-6, 1981, paper #81 WM 058-7. IEEE Trans. on PAS, Vol. PAS-100, No. 5, May 1981, pp. 2295-2301.
2. E. B. Janofsky, C.J. Durkin, "Dispatcher Simulator Training at Consolidated Edison", 1981 PES Winter Meeting, Atlanta, Feb. 1-6, 1981, paper #81 WM 033-0. IEEE Trans on PAS, Vol. PAS-100, No. 7, July 1981, pp. 3213-3216.
3. Arthur B. Storey, "The New York Power Pool Dispatcher Training Program". February, 1981 (to be published).
4. A. J. Molnar, "Dispatcher Training Course: Program Facilities and Support Requirements", 1982 PES Winter Meeting, New York, Feb. 1-5, 1982, paper # 82 WM 015-6.
5. M. P. Gorenberg, J. C. Giri, J. P. Britton, N. M. Peterson, Robin Podmore. "An Advanced Dispatcher Training Simulator," 1981 PICA Conference Philadelphia, May 5-8, 1981.
6. C. A. MacArthur, M. D. Anderson, "Power System Operator Training: Curriculum Design and Development," IEEE-PES Summer Meeting, Minneapolis, July 13-18, 1980, paper #80 SM 515-7. IEEE Trans. on PAS, Vol. PAS-100, No. 2, February 1981, p. 843.
7. J. M. Thorson, Jr., A. L. Misselt, "Analysis - The Key to Successful Electric Utility Training Courses," IEEE-PES Summer Meeting, Minneapolis, July 13 - 18, 1980, paper # 80 SM 601-5. IEEE Trans. on PAS, Vol PAS-100, No. 5, May 1981. pp 2584-2592.
8. D. R. Roth, T. T. Athnos, "Training System Management Plan," IEEE-PES Summer Meeting, Minneapolis, July 13-18, 1980, paper # 80 SM 603-1. IEEE Trans on PAS, Vol PAS-100, No. 5, May 1981. pp. 2593-2596.
9. Working Group on Operator Training (78-4) Report "Power System Operator Training Update" 1979 IEEE PES Summer Meeting, Vancouver, B.C., July 15-20, #A79 515-8.
10. Working Group on Operator Training (78-4) Report "The Problems of Operator Training" 1977 IEEE/PES Summer Meeting, Mexico City, July 1977 #A77-513-5.
11. Anderson, M. D., "Power System Operator Training" IEEE Conference "Electro 78", Boston, Massachusetts May 23-25, 1978.
12. Thorson, J. M., Jr., "A Unique Dispatcher Training Curriculum Using Advanced Simulation and One-on-One Training Techniques", 1979 IEEE/PES Summer Meeting, Vancouver, B.C., July 15-20, 1979 #A79 458-1.

13. Latimer, James R. and Masiello, Ralph D., "Design of a Dispatcher Training System", 1977 IEEE/PES Power Industry Computer Application Conference, Toronto, Ontario, May 24-27, 1977.
14. Werts, Robert W. and Perez, Jose E., "Dispatcher's Training Program", CIGRE SC32 Meeting, Minneapolis, Minnesota, May 18-24, 1979.
15. "Power System Operator Training Simulators," EPRI Workshop Proceedings (August 1979), #EPRI WS-78-128. The workshop was held in New York City, September 26-27, 1978.

<u>COURSE</u>	<u>ICS COURSE NUMBER</u>
Alternating Current Motors	4032
Protective Relaying Part 1	6538A
Protective Relaying Part 2	6538B
Alternators	4031
Voltage Regulators For Generators	4368
Line-Voltage Regulators	4369

#### IV. Reference Books

1. Robert H. Miller, Power System Operation, McGraw-Hill, 1970.
2. Olle I. Elgerd, Basic Electric Power Engineering, McGraw-Hill, 1977.
3. Olle I. Elgerd, Electric Energy Systems Theory: An Introduction, McGraw-Hill, 1971.
4. Nathan Cohn, Control of Generation and Power Flow on Interconnected Systems, Wiley, 1971.
5. L.K. Kirkmayer, Economic Operation of Power Systems John Wiley & Sons (engrg oriented).
6. L.K. Kirkmayer, Economic Control of Interconnected Systems, John Wiley & Sons (engrg oriented).
7. B. M. Weedy, Electric Power Systems, 3rd Edition John Wiley & Sons (engrg oriented).
8. B. B. Singer, Basic Math for Electricity & Electronics, McGraw-Hill, 4th Edition.
9. H. H. Happ, Piecewise Methods and Applications to Power Systems, John Wiley & Sons, 1980.

#### V. Correspondence Courses

<u>COURSE</u>	<u>ICS COURSE NUMBER</u>
Formulas	2468
Electricity Part 1	4210A
Electricity Part 2	4210B
Electricity Part 3	4210C
Electricity and Magnetism Part 1	4010A
Electricity and Magnetism Part 2	4010B
Electricity and Magnetism Part 3	4010C
Principles of A-C Circuits Part 1	4018A
Principles of A-C Circuits Part 2	4018B
Principles of A-C Circuits Part 3	4018C
Principles of A-C Circuits Part 4	4018D
Electric Power Generating Stations Part 1	6589A
Electric Power Generating Stations Part 2	6589B
Electric Power Substations Part 1	6590A
Electric Power Substations Part 2	6590B
Transformers	4040
Switchgear	6613

### Discussion

**M. R. Stambach** (Power Technologies, Inc., Schenectady, NY): PTI is now in the process of putting its two-volume operator training text material on a series of color videotapes. Production of the videoprogram is a joint venture with Leighton & Kidd, Ltd., Consulting Engineers in Toronto, Canada.

The program is approximately 40% complete and, when finished, will comprise twenty hours of videotaped material. Unlike the texts, the video program is designed to be a self-teaching package. Each tape comes with student workbooks and instructor guides. Questions and answers are included in each workbook to allow for student self-evaluation.

Manuscript received August 4, 1982.

**J. Giri and R. Podmore** (ESCA Corporation, Bellevue, WA): In response to the invitation from Max Anderson, we are pleased to submit a discussion which describes the Dispatcher Training Simulator offered by ESCA Corporation, 13010 Northup Way, Bellevue, Washington.

The ESCA Dispatcher Training Simulator operates on the VAX family of digital computers. It is capable of performing a long-term dynamic simulation of specific utility models with up to 2,000 buses in real time. The model is customized to represent a utility's specific system with an equivalent representation of the external systems of the interconnection. Unit prime-movers are represented, including a 30th-order detailed boiler-turbine-control model. Voltage, frequency, over-current and synchro-check relays are modelled. CRT screens can be updated with results from a load flow that is executed on a 4 to 10 second period. The man-machine interface is very flexible and can be customized to match the man-machine interface of an existing energy control system. The Dispatcher Training Simulator is available as a stand-alone system or as an integral part of an ESCA Energy Control System.

A stand-alone simulator was developed for Carolina Power and Light Company which emulates their existing SCADA, AGC, and Interchange Scheduling functions and displays. It uses a 1 second time-step

for updating the prime-mover models and performs a 450 bus power flow solution every 4 seconds. This simulator was delivered in January 1982 and is being used in their dispatcher training program.

Manuscript received August 6, 1982.

**P. J. Blake** (Westinghouse Electric Corp., Pittsburgh, PA): As an update to this bibliography, an additional entry under I. Suppliers/Manufacturers is suggested.

Westinghouse Electric Corporation  
Advanced Systems Technology  
777 Penn Center Boulevard  
Pittsburgh, PA 15235  
412 824-9100

Offers the TNR-500 Dispatcher Training Simulator tailored to represent the customer's power system and the MMI used by the dispatcher. Provided as a stand-alone system and also as an interconnected system with Westinghouse Energy Management Systems.

Manuscript received August 6, 1982.

**M. D. Anderson:** New developments are being made in power system operator/dispatcher training at a rapid rate. New training programs and facilities have been made available by the suppliers since the surveys were made for the preparation of this paper. The members of the Working Group on Operator Training (WG78-4) were asked to review the final version of the paper and document any updates that should be made in the form of a Discussion of this paper. This was done to provide the reader with the most up-to-date information on available training resources.

On behalf of the Working Group on Operator Training, I want to thank each of the Discussors for his or her contributions and the members of the working group who helped in the preparation of this paper.

Manuscript received September 17, 1982.