POWER TECHNOLOGIES, INC.

Background and Qualifications

For my very
good friend Shig –
[illegible]

POWER TECHNOLOGIES, INC.

Background
and Qualifications

This booklet summarizes PTI's background as a corporation, our approach to projects, and areas in which we have technical competence. It is divided into the following sections:

I. GENERAL CORPORATE INFORMATION

POWER TECHNOLOGIES INC

P.O. BOX 1058 | SCHENECTADY, NEW YORK 12301 | 518 374-1220

CORPORATE INFORMATION SUMMARY

Power Technologies, Inc. (PTI) is a consulting firm specializing in planning, design, and operating aspects of electrical power systems. The staff includes acknowledged experts in a variety of power system disciplines. The firm was organized to provide a source of advanced technical consulting services independent of manufacturing or construction interests.

THE STAFF

PTI staff is experienced in project areas where creativity, strong theoretical understanding, and practical application are equally essential. Through responsible roles in U.S. and international technical societies and standardization groups, they have worked closely with other industry experts in technical, economic, and environmental aspects of utility system development and operation.

The staff is under the technical direction of seven principal engineers:

Lionel O. Barthold	President
F. Paul de Mello	Dynamics & Control
Dale E. Hedman	Transients and Insulation Coordination
Robert J. Ringlee	System Operation and Reliability
John M. Undrill	Analytical Methods Development
John C. Westcott	Power Generation
Del D. Wilson	Experimental Programs and Distribution Systems Underground Cable Systems
Allen J. Wood	System and Corporate Planning

FACILITIES

Three in-house computer systems are maintained at PTI's Schenectady offices. These are multi-user, time-sharing facilities manufactured by PRIME Computer, Inc. Two of the systems operate interactively and share input and output peripherals. The third system is operated independently and serves Studies Center activities.

The PRIME systems drive computer terminals located throughout the building, in a study center, and at remote terminals via telephone.

PTI has developed over 25 major computer programs capable of solving highly specialized problems in electrical, mechanical, and thermodynamic disciplines. Programs range in scale from detailed representation of specific power system components to load flow and stability of interconnected systems of several thousand buses. Key programs are interactive, permitting the user to monitor and control the solution as it progresses. All programs are available for use in studies or for lease to clients.

PTI leases a fifty acre site at Saratoga, N.Y. (near Schenectady) for research and experimental programs. A variety of projects is currently in progress at the site including underground cable and overhead line research.

In 1979, PTI opened a Power Systems Studies Center to permit client companies to conduct their own studies using PTI programs and engineering guidance. The Studies Center is in the main PTI office building, but can be separately accessed for evening and weekend work.

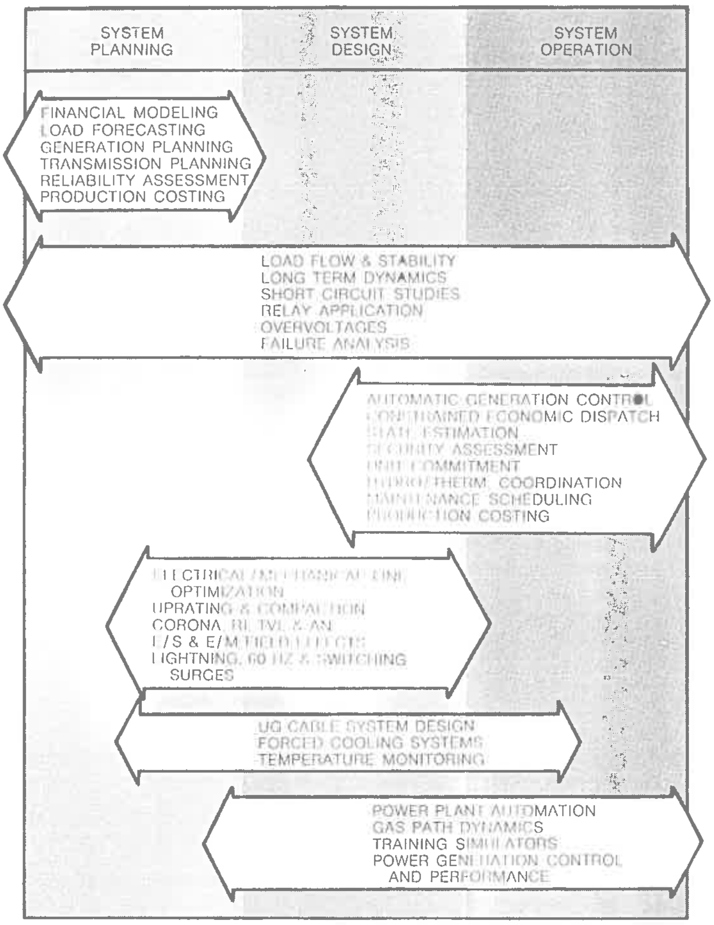
CLIENTS

PTI clients include manufacturers, architect-engineers, government agencies, and over 100 public utilities in the U.S., Canada, Latin America, Europe, the Middle East, and Australia. Contracts which would compromise objectivity in system studies or specifications are scrupulously avoided.

SERVICES OFFERED

The services offered by Power Technologies, Inc. include general consulting, organization and execution of technical studies, development of computer programs and solution techniques, research and experimental programs, analysis of equipment failures, and the conduct of educational programs. Special emphasis has been placed on enhancing the in-house capability of client companies.

AREAS OF COMPETENCE



CORPORATE DATA

PTI is entirely employee-owned and has grown rapidly since its founding in 1969. Professional staff at the close of 1979 numbered 54. Sales in 1979 were about $5.6 million. Individual projects have ranged in size from those requiring only several days' time to those exceeding ten man-years of effort.

Power Technologies International, Inc., a commonly owned company, was established in 1971 to facilitate certain foreign projects. An affiliate of PTI, Projetos e Estudos de Engenharia, Ltda (PTEL) in Rio de Janeiro, Brazil was established in 1973. PTEL computer and program capabilities are closely coordinated with PTI's.

FOR FURTHER INFORMATION

Separate bulletins are available describing specific services, computer programs, and course offerings. A list will be supplied on request.

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Power

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CORPORATE ORGANIZATION

PRESIDENT	LIONEL O. BARTHOLD							
PRINCIPAL ENGINEERS	A.J. WOOD	F.P. DE MELLO	R.J. RINGLEE	D.E. HEDMAN	J.M. UNDRILL	J. C. WESTCOTT	D. D. WILSON	
TECHNICAL SCOPE	*SYSTEM ECONOMICS & PLANNING - CORPORATE FINANCIAL PLANNING*	*DYNAMICS & CONTROL OF PLANTS AND SYSTEMS*	*SYSTEM OPERATIONS AND RELIABILITY STUDIES*	*TRANSMISSION SYSTEM DESIGN & INSULATION COORDINATION*	*ANALYTICAL METHODS DEVELOPMENT*	*POWER PLANT PERFORMANCE AND AUTOMATION*	*EXPERIMENTAL PROGRAMS AND DISTRIBUTION SYSTEMS*	*UNDERGROUND CABLE SYSTEMS*
SENIOR ENGINEERS	C.A. MacArthur W.R. Puntel M.A. Sager	H.K. Clark	W.F. B'Rells O.J. Denison, Jr. N.D. Reppen B.F. Wollenberg	S.J. Balşer R.E. Clayton S.R. Lambert J.D. Mountford	T.E. Kostyniak	E.N. Hinrichsen R.J. Mills	J.J. Burke D.A. Douglass I.S. Grant J.R. Stewart	T. Aabo J.A. Moran, Jr. J.A. Williams
ANALYTICAL ENGINEERS	M.R. Stambach	J.D. Burns K.Q. Chang J.W. Feltes L.N. Hannett B.K. Johnson P.L. Mayfield P.J. Nolan	B.P. Lam D.J. Lawrence T.A. Mikolinnas G.E. Scott G.W. Woodzell		T.F. Laskowski A.R. Weekley	J.S. Czuba R.W. de Mello D.W. Parkinson	E. Kallaur	
ENGINEERING ASSISTANTS; ANALYSTS; TECHNICIANS				PROGRAMMER: R.T. Reed		W.B. Novinger R. Guzzo	R.A. Lacy J.R. Oravsky	
SECRETARIES	M.E. Doret	M.J. Patrie	M.A. Broomhall L.H. Brown	C.A. de Mello	L.M. Roberts	C.A. Stevenson	M.N. Kane	S.J. Secor

SUPPORT STAFF

ACCOUNTANT	L.A. Wilcox	BOOKKEEPER	D.L. Dawsey
SECRETARY TO PRESIDENT	P.M. Emmer	SECRETARY	P.D. Sgroi
SECRETARY/RECEPTIONIST	B.L. Maclean		
CLERK TYPISTS	V.F. Hopson C.J. Samuels		

ASSOCIATE CONSULTANTS

K.A. Clements

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II. TECHNICAL SERVICES

POWER TECHNOLOGIES INC

Engineering Services:

INDUSTRIAL POWER SYSTEMS

P.O. BOX 1058 | SCHENECTADY, NEW YORK 12301 | 518 374-1220

BACKGROUND

PTI is a consulting firm specializing in planning, design, and operating problems of electrical power systems. Established in 1969, it is comprised of acknowledged industry experts in a variety of power system disciplines. Staff engineers have extensive experience in systems engineering, as well as in the design and application of power apparatus and control components.

PTI is independent of any equipment manufacturing interest or project implementation or construction business.

FACILITIES

PTI has an extensive library of computer programs for the design and analysis of electrical power systems. Digital facilities include in-house dedicated computers and time-share and bulk processing computers.

SERVICES OFFERED

Services offered include general consulting and trouble-shooting, the organization and execution of technical studies, preparation and evaluation of electrical system specifications, and the organization and conduct of specialized engineering courses.

Projects may be so organized as to require minimum time burden on the client's staff, or to enhance the in-house problem-solving capability of client engineers in the process of achieving study objectives.

STUDY AREAS

Load Flow - Steady state picture of normal and emergency operating conditions. Evaluate cable and transformer loading, transformer and voltage regulator tap ranges and settings, voltage drop, power factor correction (capacity release - capacitors and synchronous motors), etc.

Dynamic Simulation - Evaluate "transient stability" of generators and synchronous motors, induction motor reacceleration following voltage dips, impact loading of motors, starting of large motors, generator voltage regulator performance, load shedding.

Motor Starting - Use load flow to calculate voltage at specific points during the starting period or use dynamic simulation to examine system and motor performance (running and starting motors) throughout the start period. Examine generator excitation system performance during start.

Reliability - Evaluate relative reliability of alternative arrangements using published data or calculate reliability of unique arrangements. Matching of system reliability to process reliability requirements.

Short Circuit - Short circuit calculations by computer for existing or proposed systems for breaker and arrangement selection. Automatic calculation according to latest ANSI Standards (application guides). Calculations for relay application and coordination.

Protective Relaying - Recommendations on protective relaying according to accepted practices with special recommendations for unique conditions or situations. Determination of protective device settings for selectivity and coordination.

Load Shedding - Evaluation of credible contingencies which can cause generation shortage and plant frequency decay. Underfrequency relaying scheme recommendations considering load priority and plant electrical arrangement.

Harmonic Analysis - Harmonic control in systems with static power conversion equipment or arc furnaces. Application of filters, shunt capacitor banks or synchronous machines.

Power Factor Improvement - Analysis of plant equipment loading, voltage profile and power contract with utility. Recommendations on capacitor quantity, location and control based on economics. Synchronous motor economics.

Conceptual Design - Plant electrical distribution system recommendations and specifications based on all of the above study areas. System design based on optimum economic investment.

FOR FURTHER INFORMATION

Bulletins are available on many of the areas cited above. A complete list will be mailed on request.

Requests for bulletins, additional information or quotations on specific engineering projects should be addressed to:

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POWER TECHNOLOGIES INC

Engineering Services
UNDERGROUND CABLE SYSTEMS

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COMPANY BACKGROUND

PTI is a consulting firm specializing in the planning, design, and operating functions of electrical power systems. The firm was established in 1969, and has as its staff acknowledged industry experts in a wide variety of power systems disciplines.

The firm was established to provide an independent source of advanced technical consulting services to utilities and organizations concerned with utility operations.

STAFF

Members of the PTI Underground Cable Systems group have extensive background and experience in all areas of the field, including:

- Basic dielectrics
- Cable and accessory design and manufacture
- Quality control during manufacturing and intallation
- Economic studies of alternative transmission systems
- Cable system design, specification, and installation
- Preparation of specifications and evaluation of bidders for material and installation
- Factory acceptance tests
- Consultation on construction operations
- Operation and maintenance of cable systems
- Research and development in advanced underground transmission systems

CLIENTS

PTI clients include over 100 major public utilities, manufacturers, architect-engineers, and government agencies. Contracts which would compromise objectivity in any aspect of PTI activities have been scrupulously avoided.

SPECIFIC AREAS OF COMPETENCE

Economic Analysis

- Alternative underground transmission systems: pipe-type cables, spacer-gas systems, LPOF duct or direct burial systems, extruded cables, dc cables
- Forced cooling for new cables or to uprate existing cables
- Deferrable expenses according to load growth
- Evaluation of operation and maintenance charges

Specifications and Bid Evaluations

- Selection of cable type
- Preparation of purchase specifications for cable and accessories, including hydraulics
- Specifying installation work to be performed
- Evaluation of bidders for material, installation
- Qualifying of new manufacturers
- Analysis of factory test results

Installation

- Pulling tension calculations - optimize section lengths
- Testing of pipe - radiographic, pressure, and vacuum testing
- Corrosion protection of pipe
- Splicing supervision and installation conditions
- Vacuum testing of completed line
- Oil handling
- Acceptance test levels

Operation and Maintenance

- o Thermal monitoring
- o Methods for oil sampling, testing, analysis
- o Test equipment specification
- o Field testing of suspect lines
- o Fault location, analysis, and repair
- o Emergency operation

System Engineering

- o Bulk power system planning and economic evaluation
- o Transient voltage analysis
- o Load division
- o Short circuit studies and relay applications

Dielectric Systems

- o Laboratory programs for materials evaluation
- o Economic analysis for novel materials
- o Composite dielectrics, synthetic papers
- o Low viscosity oils for forced cooling

Ampacity

- o Determination of required cable size
- o Ampacity of joints re cable ampacity
- o Underwater installations
- o Hot spot derating and amelioration
- o Temperature monitoring methods

Compressed-Gas Insulated Systems

- o Economic analysis of system
- o Specification of material, equipment
- o Special jointing procedures
- o Field testing
- o Operation and maintenance procedures

Forced Cooling

- o When is forced cooling economically justified?
- o Uprating existing lines
- o Choice of cooling system: oil/air, oil/water, mechanical refrigeration
- o Design of hydraulic circuits
- o Use of low viscosity dielectric fluids
- o Consideration of joints and potheads as possible thermal bottlenecks
- o Preparation of equipment specifications

Special Problems

- o Environmental impact
- o Vertical risers
- o Extended cable storage

FOR FURTHER INFORMATION

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ENGINEERING SERVICES

Power Generation

The past fifteen years have seen major changes in both design and operating requirements of generating plants. Stringent new requirements on emissions have increased initial costs and reduced operating efficiency. Fuel costs and availability have changed drastically during this period, financing costs have soared, and increased concern over availability has required more sophisticated centralized control to aid operators to attain better plant performance.

These factors, coupled with an astonishing pace of development in computer and control hardware, have expanded the role of dedicated computers in the operation of power plants and have demanded that greater pains be taken in the simulation of plant processes in the design stage, acceptance testing and performance monitoring during operation.

PTI staff have been leaders in the development and application of analytical methods to power plant technology during this period. This bulletin will illustrate some specific areas where PTI can contribute both to purchasers and suppliers of generating plants.

POWER PLANT CYCLE ANALYSIS

Selection of generation equipment is partly determined by expected performance of various cycle components. Evaluation of the effects of varying component performance characteristics on the overall plant performance is necessary to fully evaluate component worth. One example would be to evaluate the effect of different condenser heat rejection systems on turbine last stage bucket loading and the worth of different sizes of last stage buckets.

PTI is developing a program for total cycle analysis applicable to any power generating system incorporating steam turbines. This includes nuclear and fossil fueled units with regenerative feedwater heating and various methods of condenser heat rejection and the combination of these with various types of combustion turbines with exhaust heat recovery.

POWER PLANT INFORMATION AND CONTROL SYSTEMS

Modern fossil and nuclear fueled power plants have become too complex for human operators to adequately control. Computers are almost universally used in operator information systems on large units. There is a growing application of them to control particularly during startup.

Engineers at PTI have had many years of experience in the following applications:

1. Total information and control requirements evaluation as a preliminary step in preparation of functional specifications and review of vendor proposals.

2. Development of direct digital control (DDC) definitions for steam generators and the startup and shutdown of steam turbines.

3. Evaluation and/or recommendation of instrumentation necessary for monitoring, control, and performance evaluation.

This would include the following:

a. Required types of instrumentation including determination of the optimum location for the most reliable determination of the process variable.

b. Definition of required computer interface and conversion equations.

c. Installation procedures and initial and continuing calibration requirements.

4. Plant operating optimization which considers maximizing the net generation of the unit while considering the constraints imposed by system reserves and environmental considerations. Examples are:

a. Cooling water management particularly in applications using mechanical draft wet or combined wet/dry cooling towers.

b. Variable pressure operation using methods tailored to a utility's specific requirements for spinning reserve.

5. Contingency effects evaluation for the plant auxiliary's electrical system. This function embraces such performance tests as checking auxiliary bus voltage caused by switching of auxiliary supplies, etc.

POWER PLANT PERFORMANCE ANALYSIS

The analysis of plant performance is becoming increasingly important. Increased fuel costs, necessity of decreased forced outage and better information for economic dispatch, all require better performance such as:

- Turbine acceptance tests.
- Plant component tests.
- Unit heat rate determination for economic dispatch, deterioration analysis and planned maintenance.

PTI is uniquely qualified to serve as a disinterested referee if it is necessary to determine the acceptability of tests of plant equipment.

OPERATOR TRAINING SIMULATORS

PTI's engineeers have been involved in the design and implementation of power plant simulators for operator training. This training is required for all operators of nuclear fueled units and some utilities are planning the same type of training for fossil fueled units.

Our services are available for the following:

- Functional and detailed specifications for hardware, software and reference material.
- Proposal evaluation.
- Software development - thermal, mechanical, and electrical systems.
- Instructor training.
- Total project management.

EDUCATIONAL SEMINARS

PTI offers seminars which can be tailored to a client's particular requirements. Areas covered are:

- Power plant performance monitoring and evaluation.
- Instrumentation systems including measurement criteria, accuracy requirements, hardware limitations, computer interface and calibration techniques.
- Control system fundamentals for steam generator control by both analog and digital systems, control tuning criteria and simulation techniques for control system design and analysis.

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Engineering Services:

ENERGY CONTROL CENTERS

The U.S. has long enjoyed a position of leadership in the technology of monitoring, analysis, and control of large interconnected power systems. Progress in both hardware and software aspects of energy control centers has been given new impetus in the past decade by three factors; (1) Increased concern over system reliability, made more difficult by delays in power plants and lines, (2) Pollution controls and rapid shifts in fuel availability or cost, (3) Astonishing progress in both computing and communication hardware - allowing more freedom in choice of system hierarchy and (4) The emergence of a new generation of suppliers to the industry, both in system integration and application software.

With this accelerated pace of development, it is important that new control centers or expansion in existing centers take full advantage of current technology but also be so structured as to accommodate continuing developments in both hardware and application software.

APPLICATION SOFTWARE DESIGN AND APPLICATION

PTI has been an industry leader in the development and practical application of computer programs supporting the operation, control and security assessment of larger interconnected power systems. Clients include three major power pools, eight utilities, and five system and/or hardware suppliers. Examples of PTI-developed programs are:

- o Applications Software Design
  - Automatic Generation Control Programs to monitor area load interchange and unit control status, to maintain scheduled frequency and net interchange by generation allocation.
  - Economic Dispatch Programs to allocate generation economically among available thermal units, and provide for economic following of load changes. Developed ED's for both single area and multi-area dispatching.
  - Unit Commitment Scheduling Programs to economically select the proper mix of fossil steam and combustion turbine units to meet forecast loads and follow load changes with minimum operating costs, while maintaining adequate system reserves.
  - Contingency Analysis Programs to monitor system security by evaluating preassigned line and generation outage contingencies. Checks resulting line loadings and generator load pickup requirements.
  - Operator Load Flow Programs for study purposes to assess network flow conditions. Ease of operation attained by minimizing operator-required input and facility for edited output including CRT displays are features of these programs.
  - Reserve Assessment Programs to allow a probabilistic evaluation of the adequacy of operating and spinning reserve margins.
  - State Estimation Programs to utilize system measurements for the purpose of estimating system voltage and phase angle conditions, thereby providing improved, updated data for other programs.
  - Voltage Scheduling & Control Programs to maintain predetermined network voltage profiles by utilizing bus voltage control equipment, shunt reactors, and capacitors, and tap changers at all accessible locations.
  - Network Topology Programs to determine the substation and network configurations, taking into account all switching and breaker operations, as well as line outage conditions. This information is necessary to provide dispatchers with bus, circuit and network status, to provide the necessary network configuration information for application programs, and to allow detection and alarm of conditions which could result in system separations.

- Interchange Negotiation Programs to allow parties to examine the economic and unit scheduling dimensions of the interchange transaction under negotiation.

CONTROL AND COMMUNICATION SYSTEM PLANNING AND SPECIFICATIONS

Exposure to a wide variety of system practices, operating problems and equipment resources, both within the United States and other countries, together with an independent posture in the industry, gives PTI staff members unusually strong qualification for the planning and specification of energy control systems including:

- o Hardware
- o Operations and Applications Software
- o Man/Machine Interface
- o Data Bank Design

SEMINARS AND TRAINING

As in other disciplines, PTI has incorporated both practical and theoretical aspects of energy control into a variety of seminars covering such topics as:

- o Hardware
  - Control Centers
  - Telemetry
  - Information Processing
  - Display Systems
- o Software
  - Real-time Operating Studies
  - Real-time Data Base
  - Input/Output Software Systems
  - Automatic Generation Control
  - Stages in Planning an Energy Control Center

PROJECT EXPERIENCE

The following list cites examples undertaken by PTI in this technical area. Names of clients will be supplied on request.

Power System Operation and Control Studies

- o Consultant to an Eastern power pool control center group in the development of application programs for economic dispatch, LFC, unit commitment, security, etc.
- o Consultant to power pool on operating reliability and general software development by in-house staff.
- o Developed programs to analyze historic outage records to prepare unit/plant outage statistics for setting operating reserve level and programs for assessment of reserve risk for major U.S. pool.
- o Consultant to manufacturer of compuer equipments in the development of models, specifications, and software for power system data acquisition, monitoring, and control.
- o Consultant to major manufacturer of power system protective devices and systems.
- o Consultant to computer manufacturer on application of minicomputer to utility industry.

- o Software development for a nuclear plant operator training simulator.
- o Detailed control dynamics and surge calculations and followup testing for large underground hydro plant in New Zealand.
- o Consultant to electronics manufacturer on software requirements for a fossil-fired power plant operator training simulator.
- o Development and reduction to practice of an advanced dispatch method which uses transmission incremental losses determined directly from a real-time network status and flow estimates.
- o Development and reduction to practice of advanced methods for transactions evaluations utilizing real-time and study data.
- o Development and reduction to practice of advanced methods for unit commitment scheduling recognizing practical operating constraints.
- o Development and implementation of a large scale operator load flow program for a major Eastern power pool.
- o Development and reduction to practice of an advanced network topology and state estimation programs.

Power System Communication

- o Relate system communication and system control requirements under contract to a U.S. supplier.
- o Review of communication system expansion plans for a major utility system in Brazil.

FOR FURTHER INFORMATION

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Engineering Services:

UTILITY SYSTEM DESIGN

INTRODUCTION

Utility System Design requires study of highly complex technical, economic and operational aspects of systems. While individual tasks may be defined clearly, most of them are so interrelated that an orderly and efficient approach to the total problem places a heavy burden on prior experience and judgment as to problem-solving sequences.

Figure 1 portrays the nature of interdependence between study areas in a typical design study for bulk power transmission from a major generating plant. The coupling between study areas is indicated by the weight of the mutual which embodies another dimension of factors relating one study area to another.

FIGURE 1

Interdependence of Study Areas

	1) System Configuration	2) Series X - Rating, Location and Protection	3) Shunt X - Rating, Type and Location	4) Excitation and Governor System Characteristics	5) Hydraulic System Dynamics	6) Transmission Line Design Criteria	7) Transmission Equipment Characteristics	8) Substation Configuration	9) Protective Relay System Design	10) Operating Requirements
1) System Configuration		X	X	X	X	X	X	X	X	X
2) Series X - Rating, Location and Protection	X		X	X		X	X	X	X	X
3) Shunt X - Rating, Type and Location	X	X		X	X	X	X	X	X	X
4) Excitation and Governor System Characteristics	X	X	X		X		X		X	X
5) Hydraulic System Dynamics	X		X	X			X		X	X
6) Transmission Line Design Criteria	X	X	X				X	X	X	X
7) Transmission Equipment Characteristics	X	X	X	X	X	X		X	X	X
8) Substation Configuration	X	X	X			X	X			X
9) Protective Relay System Design	X	X	X	X	X	X	X			X
10) Operating Requirements	X	X	X	X	X	X	X	X	X	

In dealing with problems of this magnitude, experience has shown that detailed modeling and analysis at the early stages will often make the difference between feasibility and nonfeasibility of basic alternative solutions.

PTI has been an industry leader in the conduct of highly complex system design studies where a combination of technical skills, experience and use of very efficient interactive power system analysis programs has made it possible to examine alternative solutions quickly from various performance aspects and arrive at the optimized solution.

An example of interrelated tasks that typically must be performed in utility system design is given in Figure 2.

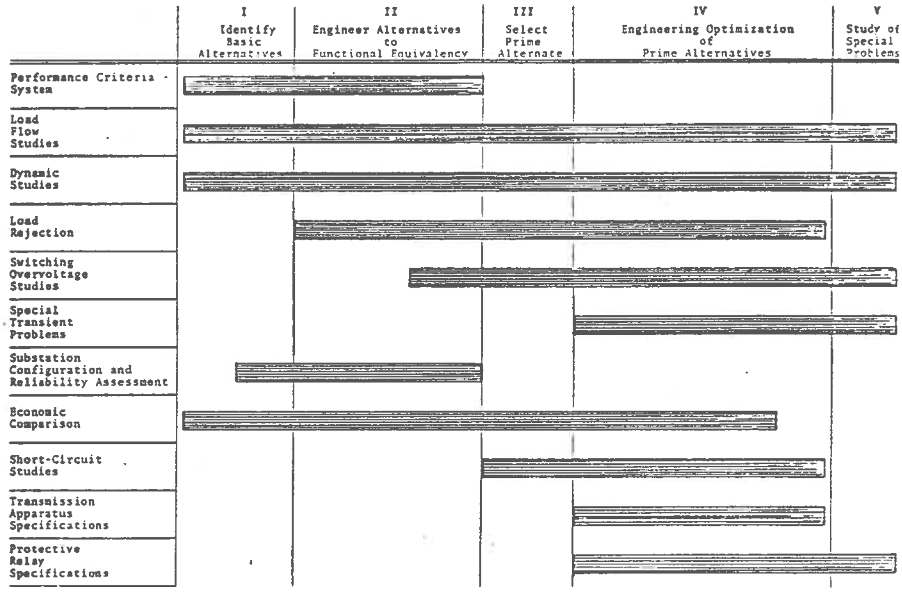

FIGURE 2
Example Task Organization

FACILITIES

PTI has developed an extensive library of computer programs for the analysis and design of utility systems. The most important and widely used of these programs is the Power System Simulation program package (PSS/E) developed for interactive use on dedicated CRT-based computer systems, (see Bulletin PTI/91). This program package provides load flow, short circuit, equivalencing and dynamic analysis capabilities for systems up to 4000 buses with wide range equipment modeling capability. Convenient presentation of results in plots (Figures 3 and 4), and on CRT, enhance the depth of investigations and efficiency of study executions. The dynamic analysis programs can accommodate frequency dependence of network parameters, saturation of reactors and transformers typically required in load rejection or system islanding studies.

Other powerful computer programs for special studies of plant dynamics, subsynchronous resonance, etc. which must sometimes be done are the IDAP program (Bulletin PTI/67), and the Machine and 3 Phase Network Transients program, MNT/E (Bulletin PTI/92).

Extensive in-house PRIME computer systems permit the conduct of large system studies at PTI. Special computer and peripheral facilities are available for direct use by clients at the PTI Study Center (see Bulletin PTI/110).

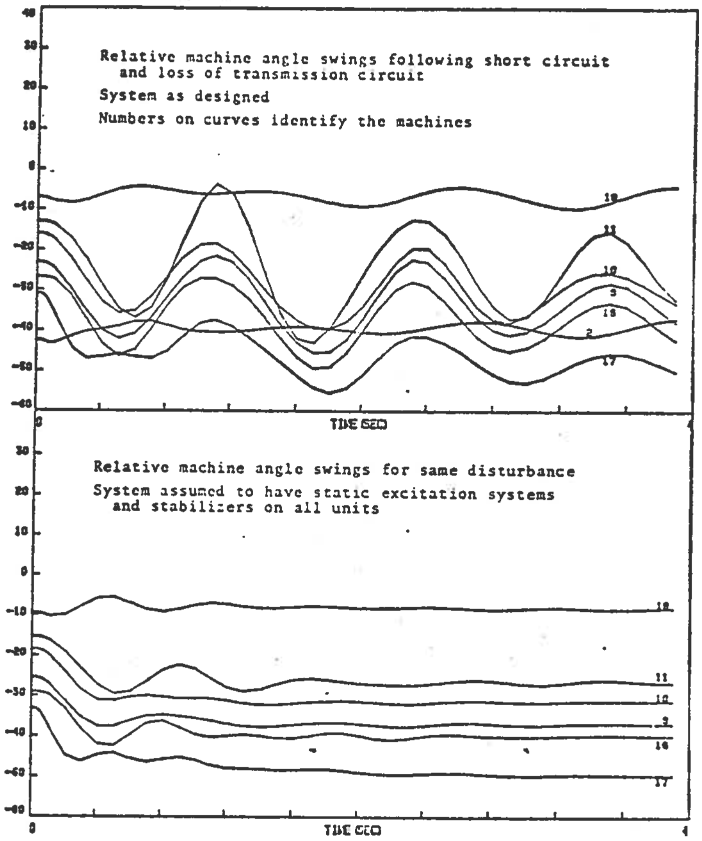

FIGURE 3

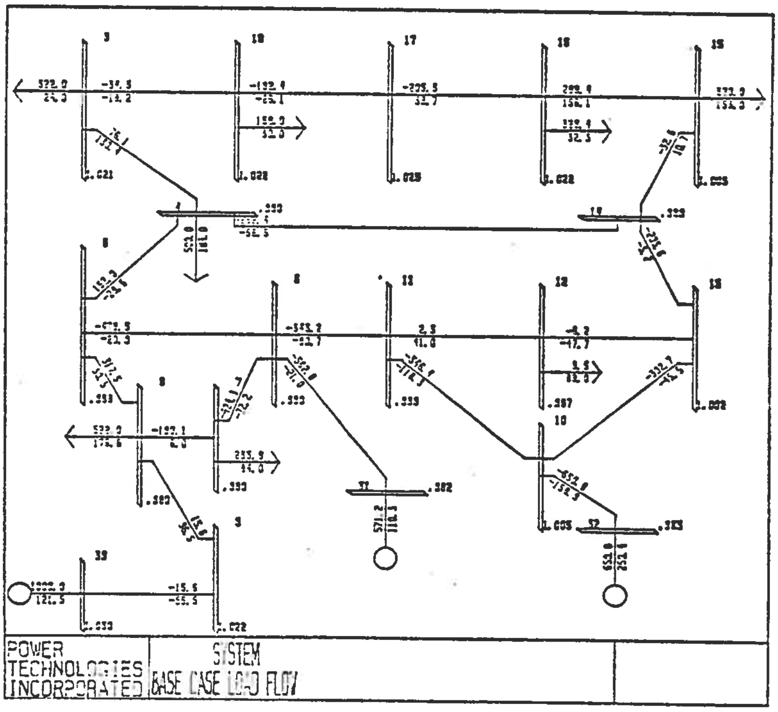

FIGURE 4

PROJECT EXPERIENCE

- o Comprehensive system design studies, extending from voltage choice and system configuration to detailed functional specifications of transmission and generation equipments for fourteen major systems including utilities in the U.S., Mexico, Venezuela, Brazil, Canada, and Argentina.
- o Studies of substation configuration for reliability assessment. (See program described in Bulletin PTI/77.)
- o Studies of shunt reactor applications for several utilities and for a major manufacturer.
- o Studies of series capacitor applications including frequency response analysis of subsynchronous oscillations and time response simulations of currents, voltages and shaft torques. (See Bulletin PTI/88.)
- o Studies of load rejection overvoltage transients including harmonic effects. (See Bulletin PTI/92.)
- o Turbine governor and hydraulic system design studies for hydro plants.
- o Analysis of failure causes in a major urban network.
- o Consultant to a major manufacturer of power system protective relays in application of advanced design concepts.
- o Analysis of causes for specific equipment failures for manufacturers, utilities, government agencies and insurance companies.
- o Testimony preparation and expert witnesses on system design and need for new facilities, both for utilities, state agencies and public interest groups.
- o Analysis of dynamic performance of wind-turbine systems.
- o (See also PTI Client List - Bulletin PTI/21.)

FOR FURTHER INFORMATION

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POWER TECHNOLOGIES INC

Engineering Services:
OVERHEAD TRANSMISSION LINE
AND SUBSTATION DESIGN

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Techniques for design of overhead transmission lines and transmission substations have evolved rapidly in the past decade, spurred by the technical and economic problems associated with EHV and UHV facilities. More recently, SF_6 substation technology and research in compact construction of intermediate voltage lines have added to the options available to transmission system designers.

PTI professional staff have played a leading role in this evolution, both through work in industry research projects, and in the application of advanced engineering methods and data to the optimized designs of transmission lines and substations.

The scope of PTI's work in line and substation design technology includes:

ELECTRICAL/ MECHANICAL OPTIMIZATION OF BASIC LINE DESIGN

PTI line optimization studies may begin at the point where a variety of alternative transmission towers are being considered, sometimes before the voltage level itself has been established pending more precise line costs. To converge efficiently on the optimum tower, conductor choice, span and overall design dimensions, PTI developed a gradient analysis method which permits simultaneous evaluation of both electrical and mechanical parameters for a wide variety of alternatives. This method, embodied in PTI's LOP-I program (see Bulletin PTI/72) is the starting point for more detailed studies of other design questions.

It can, in combination with other PTI programs, make use of a comprehensive statistical definition of weather parameters as they influence both electrical and mechanical design criteria.

TOWER DESIGN

Conceptual tower designs can be defined and predesign loading clearance matrices developed.

LIGHTNING PERFORMANCE

Studies of anticipated lightning tripout performance, including consideration of shield locations, insulation levels, tower grounding method, and various ambient conditions are usually undertaken in close coordination with other aspects of the mechanical/electrical design problem of a new line design.

Apart from background in the theoretical aspects of lightning tripout, PTI has a variety of computer programs which can expedite solutions for both single- and double-circuit towers, including effects of differential insulation.

POWER FREQUENCY INSULATION LEVEL

PTI's direct involvement in insulator contamination research programs and long experience in the operating records of transmission lines in areas of high contamination, provide strong credentials in this aspect of insulation selection for both transmission lines and substations.

SWITCHING SURGE PERFORMANCE

Several of PTI's lead engineers were instrumental in the introduction of probabilistic methods in the selection of power system insulation and in the introduction of these methods in U.S. and international standards. Computer programs developed at PTI accurately predict (1) probabilistic insulation strength variations with time and weather, and (2) probabilistic distributions of switching overvoltages (See Bulletin PTI/41). Together, these programs optimize the choice of insulation and clearances for transmission lines, substations, and equipment. The methods are applicable for both unprotected insulation and insulation which is coordinated with surge arresters.

SUBSTATION AND EQUIPMENT SPECIFICATION

PTI studies extend to functional specifications for substation equipment, e.g., transformer insulation levels, surge arrester discharge current, circuit breaker recovery voltage, series capacitor gap requirements, etc. Specifications of this kind depend in part on system studies (see Bulletin PTI/5). Choice of the best bus configuration, for example, will depend on network reliability solutions (see Bulletins PTI/77 and 78), reliability and repair times of proposed substation equipments, dynamic and transient characteristics of the system and often on cost or space constraints.

VOLTAGE UPRATING

A number of PTI studies have been directed to uprating lines and substations to higher voltage levels. In most cases, this has been achieved without increases in spacing. Research conducted by PTI on design, construction, and operation of a 1/2-mile, highly compact, 138 kV test line has provided valuable support for the prospect of uprating existing facilities.

ENVIRONMENTAL COMPATIBILITY

PTI staff members have a broad range of experience in both theoretical and design-related aspects of such problems as:

- Radio and Television Noise
- Audible Noise
- Electrostatic and Electromagnetic fields
- Electric shock hazards

This experience is supplemented by a library of advanced computer programs in all of the above areas.

This background has been widely applied in line design, environmental impact hearings and in litigation.

PROJECT EXPERIENCE

The following list contains samples of transmission line and substation design projects undertaken by PTI. Names of clients and more specific data are available on request.

- o 550 kV study including optimization of electrical and structural line design, switching surges, lightning tripout, electrostatic and electromagnetic coupling, SF_6 substation design, transmission equipment specification, insulation coordination, radio noise, and test requirements.
- o Selection of voltage level (550 kV), optimization of electrical and structural line design, load rejection, switching surges, lightning tripout, transmission and substation equipment specifications, insulation coordination, radio noise, voltage gradients at ground level, and tower spotting.
- o 800 kV study including review of voltage level, ac vs. dc alternative reactive compensation, insulation requirements, electrical and structural optimization of line design.
- o 800 kV study including electrical and structural optimization of line design.
- o 550 kV study including switching surges, load rejection, substation equipment specifications, and insulation coordination.
- o 362 kV study including switching surges, load rejection, substation equipment specifications and insulation coordination.
- o Analysis and cause assessment of several EHV substation equipment failures.
- o Analysis and cause assessment of transmission line ground wire failures.

- o Design, construction and installation of a large transient network analyzer.
- o Research and development of compact transmission line designs including construction and experimentation on a 1/2-mile test line and analytical modeling of conductor motion.
- o Hazard analysis for EHV live line maintenance.
- o Market and design research for novel EHV equipment alternatives.
- o Expert witness at various transmission facilities hearings.
- o EHV radio interference, tv interference and audible noise studies.
- o Environmental impact of 800 kV lines, electrical considerations.

COMPUTER PROGRAMS

The following list contains programs developed by PTI for use in transmission line and substation design studies.

- o Transmission Line Optimization Program
- o Conductor Ampacity Program
- o Lightning Tripout Program
- o Switching Surge Performance Program
- o Station Insulation Contamination Program
- o Conductor and Earth Electric Field Program
- o Electrostatic and Electromagnetic Coupling Program
- o Radio Noise Program
- o Audible Noise Program
- o Weather Model Program

SEMINARS AND COURSES

PTI conducts seminars and courses in the various aspects of transmission line and substation design listed in the above summary.

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POWER TECHNOLOGIES INC

ENGINEERING SERVICES

ELECTRIC UTILITY CORPORATE MODELS

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INTRODUCTION

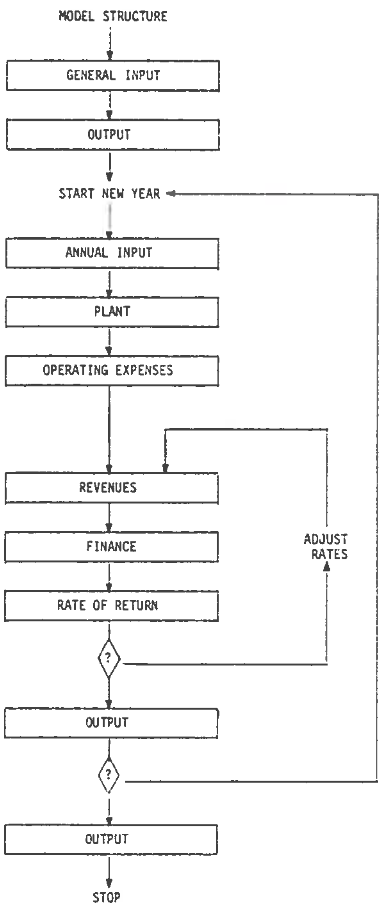
Utility plans must be examined in light of financial feasibility. Construction plans that are "economic" when viewed over the long run may, in fact, exceed the expected financial capability of the organization. Corporate models provide the means for integrating the diverse views of the engineer, the rate analyst, the depreciation expert, the financial analyst and the utility executive to provide forecasts of financial needs, requirements for rate actions and the impact of possible future price level changes.

Corporate models are digital computer programs for use by utility management as a tool in financial and engineering planning studies. They contain economic, engineering, financial management submodels simultaneously interacting. Typically, these models have been used in the electric utility industry to make the following types of investigations:

- Financing needs for system growth
- Evaluation of alternative construction plans
- Market studies
- Studies of expected energy production expenses
- Effect of varying financial markets

MODEL STRUCTURE

A block diagram of a typical, complete utility corporate model is shown in the figure below. This form of model is a collection of the major subsystem models and may be as simple or complex as the model builder requires.



ELECTRIC UTILITY CORPORATE MODEL STRUCTURE

PTI staff members have pioneered the development and application of these models in the utility industry. The corporate model consists of two separate major submodels.

- An annual or monthly financial model program used to produce forecasts of cash flows, financial needs, and income and balance sheet account data.
- An energy production cost program plus related subsidiary programs designed to produce forecases of fuel consumptions, fuel and unit operating costs and the costs and revenues associated with energy and capacity transactions.

The financial models developed with PTI assistance have usually been tailored for a specific utility while production cost programs may be general or tailored for specific utility conditions.

The output of a financial model is a series of forecast financial statements, cash flow reports and statistical data. Annual financial models have been developed which produce projections of revenues, expenses, financing needs and earnings. These range from relatively simple models using a small amount of published economic data to more complex versions requiring a large number of data sequences.

Monthly financial models are necessary in forecasting cash flows and investigating the timing of new financing. Monthly models need to be tailored for the specific organization. Models have been built with PTI's assistance of individual corporations, governmentally sponsored utilities and multi-company, multi-utility holding companies.

These models incorporate various degrees of detail and sophistication. In all cases, it has been intended that the model structure would remain dynamic and be changed by the utility staff as conditions were altered.

The production cost program produces monthly and annual forecasts of systems' energy costs and revenues from inter-company transactions. A "standard" production cost program may be supplied "off the shelf" for a system with predominately thermal generation. This standard program will simulate:

- the operation of a maximum of 150 thermal units
- the action of several hydro-electric plants
- the effect of unit forced outages in curtailing the operation of nuclear and other base load units and increasing the operation of the peaking units.

For hydro-thermal systems, or systems with major pumped storage hydro plants, the production cost program should be tailored for the specific system conditions. For some other systems, special features may have to be added to the production cost program to handle the simulation of such things as:

- take-or-pay fuel contracts
- units fired with two fuels
- participation unit sales,

and so on.

RELEVANT PROJECT EXPERIENCE

The following list cites examples of work undertaken in the area of corporate modeling. Names of clients will be furnished upon request.

- Construction of financial models for six major U.S. utilities.
- Consulting assignments in the corporate model area for several U.S. and foreign utilities.
- Seminars on corporate models presented in Australia, West Germany and Sweden.
- Fifteen hour course "Introduction to Utility Economics and Finance" given to several hundred engineers.
- Development of generalized utility corporate models for use in studying nuclear fuel, leasing as an alternative to ownership, and energy storage devices.
- Consultant to a major U.S. manufacturer in the area of utility financial problems and the potential impact on system growth.
- Development of production cost programs for fuel budgeting, weekly operation and longer range planning studies of a mid-western power pool.
- Development of production cost planning program with specialized models of units with mixed fuel firing and unit sales contracts.
- Development of models to represent combined cycle units for a power pool model.
- Development of a model of a hydro-thermal system for a south-western utility. The hydro system included four hydraulically coupled storage and pumped storage plants.
- Development of a generalized model for optimal generation expansion planning.
- Development of a generalized production cost program to evaluate the economic benefits of energy storage devices.

ARRANGEMENTS FOR SERVICES

In the development of financial models, PTI would prefer to work with a client team. PTI will supply consulting services or take complete responsibility for program development.

Complete documentation and instruction is provided with any PTI program.

The standard PTI production cost program is available. Special programs for complex hydro-thermal systems, pumped storage plants and so on can be developed also.

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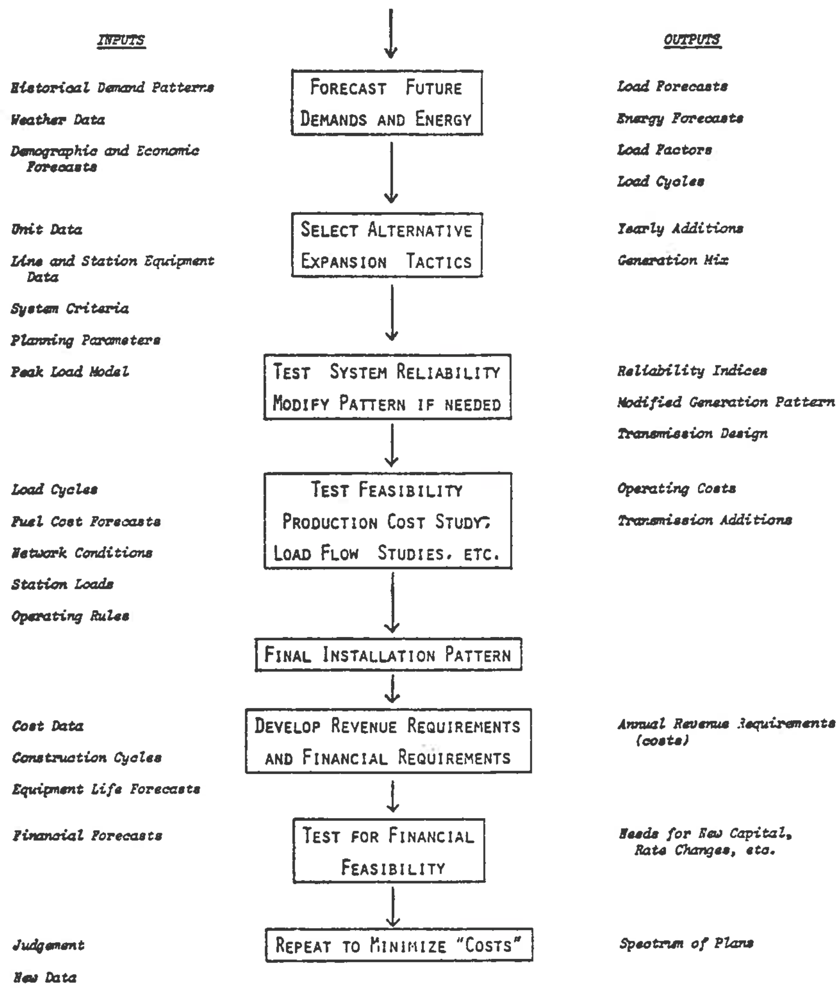
INTRODUCTION

Utility system planning involves almost every phase of electric utility activities from forecasting load demands to studying the financial capability of the utility to support the planned system development. Power Technologies, Inc. has been active in this complex area, particularly in the development of models and tools for bulk power planning. The functions of planning, system design and system operation and control are, of course, so interrelated that system planning must encompass all of them.

The figure below illustrates the bulk power planning process in simplified form. None of these activities are really independent of the others nor is the whole process independent of the necessity for detailed system design and operating studies. Systems must be both operable and affordable as well as being economic and capable of surviving mishaps and abnormal conditions.



Simplified Block Diagram of the Bulk Power Planning Process

PTI staff members have been involved in the developments and practical application of many of the fundamental methods and tools used in this area. The growth in utility systems coupled with the ever changing economic, financial and environmental conditions in which utilities must operate mandates the need for continued excellence in planning electric power systems.

APPLICATIONS IN ENERGY SYSTEM PLANNING AND ANALYSIS

Power Technologies has been an industry leader in the development of techniques, computer programs and their practical application for the planning, analysis, and operation of electric power generation and transmission systems. Clients in the area of bulk power planning have included a large number of utilities, both in the U.S. and abroad, five major power pools, the U.S. Atomic Energy Commission, the Energy Policy Planning project sponsored by the Ford Foundation, a major nuclear consulting firm, and several major manufacturers and suppliers of electrical apparatus.

Computer Programs and Methods

PTI has developed models to simulate the operation, economics and financial aspects of both investor owned and government sponsored electric utilities. The following are examples of methods and programs developed by PTI.

- Generation System Reliability and Planning - This program provides a means to study the expansion and reliability of generation systems. The systems are planned to meet a given reliability index, either the "loss-of-load probability" or a measure of the frequency and expected durations of generation margin shortages, (see Bulletin PTI/64).

- Generation Production Cost Programs - These programs are simualtions of the operation of the energy supply systems including generation, energy storage units, and energy or power purchases and/or sales from interconnected utilities. The load models used in these programs are generally typical daily load cycles for the deterministic type of programs or expected load distributions for the stochastic versions. These programs develop the expected costs of supplying the forecasted load taking into account the operating rules, commitment and spinning reserve requirements of the system or pool. Programs have been developed for long and medium range planning where the time span is a number of years and the primary interest is in the prediction of costs. For operational planning purposes the emphasis is on the detailed simulation of the operating rules and unit characteristics, so that the time spans considered are usually a day to two weeks at the most. In all versions the simulation is based on achieving optimum operation, (see Bulletin PTI/52).

- Optimal Generation Planning - This type of program considers both the investment and operating cost of various types of generating units and/or energy and power sources. The method used by the PTI program is based on a forward, truncated dynamic programming approach. In order to develop optimal economic power generation systems a degree of approximation beyond that used in the usual production cost program is required in the modeling of both the loads and the generating units, (see Bulletin PTI/68).

- Transmission Planning - PTI has developed and applied a new automatic transmission planning program which will develop an economically optimum transmission system. The method is based upon a gradient technique which makes use of an adjoint electrical network to determine network sensitivities. The program can expand existing systems or consider the development of a completely new system, (see Bulletin PTI/89).

- Utility Corporate/Financial Models - These methods and programs are designed to facilitate the study of the economics of utility operations (taken in the broadest sense) recognizing the financial aspects of the situation. These models have been developed for both investor owned utilities in the U.S. and for governmentally sponsored utilities in the U.S. and other countries. The complete corporate model involves the integration of the financial model, the production cost model and a special model to represent the complex engineering accounting and financial aspects of nuclear fuel.

- Specialized Models for Energy Storage Systems - Several specialized production cost, operating simulation models have been developed to study the impact of energy storage. These have involved both hydraulically complex pumped storage hydro-electric systems as well as other types of energy storage devices.

RELEVANT PROJECT EXPERIENCE

The following list cites examples of technical work undertaken in the area of power system planning. Names of clients will be furnished upon request.

- Development of a generation reliability and expansion program.
- Tailoring of this program for use by non-utility personnel to study future alternatives for the U.S. power system.
- Development of automated transmission planning program
- Development of several investment cost programs
- Study of the reliability and expansion of a large hydro-thermal system involving a special energy reliability model.
- Study of the expansion of a major midwestern power pool.
- Development of load modeling programs to furnish load models for generation reliability and planning studies.
- Programs to analyze outage rate data for generation units.
- Development of weather sensitive load forecasting program for a major southern utility concerning a large area.
- Consultant to a midwestern utility in a federal regulatory matter.
- Consultant to a southern utility in a rate hearing involving generation system reliability planning and capacity interchange requirements.
- Consultant to state power system facilities commission dealing with transmission system growth.
- Consultant to a state agency on a reliability study of an underground network.
- Numerous consulting assignments involving the application of underground cable systems, both conventional and advanced or exotic.
- Development of general model for analysis of the nuclear fuel lease versus purchase problem.
- Development of production cost programs for fuel budgeting, weekly operation and longer range planning studies of a mid-western power pool.

- Development of planning program with specialized models of units with mixed fuel firing and unit sales contracts.
- Development of models to represent combined cycle units for a power pool model.
- Development of a model of a hydro-thermal system for a southwestern utility. The hydro system included four hydraulically coupled storage and pumped storage plants.
- Development of a generalized production cost program to evaluate the economic benefits of energy storage devices.
- Construction of financial models for six major U.S. utilities.
- Consulting assignments in the corporate model area for several U.S. and foreign utilities.
- Seminars on corporate models presented in Australia, West Germany, and Sweden.
- Development of generalized utility corporate models for use in studying nuclear fuel leasing as an alternative to ownership and energy storage devices.
- Consultant to a major U.S. manufacturer in the area of utility financial problems and the potential impact on system growth.
- Consultant to southwestern utility holding company in controversial interconnection studies and hearings before several federal agencies.

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POWER TECHNOLOGIES INC

EXPERIMENTAL SITE AND FACILITIES

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SITE AND FACILITIES

Power Technologies, Inc. operates a 50-acre experimental facility located within the 445-acre Saratoga Research and Development Center in Ballston Spa, New York. The Center is located south of Saratoga Springs, approximately a 25-minute drive from either the Albany County Airport or Schenectady. An isolated and undisturbed environment is provided that has been used in support of industrial, aerospace, and military projects.

PTI leases the 50 acre site, plus improvements, from New York State. The facilities include office space, light machine shop, fabrication and model shop, a 138 kV substation, cleared transmission line R.O.W. and a large indoor test area with data acquisition and computer systems. The photograph below is an aerial view of the site.

Saratoga Research & Development Center

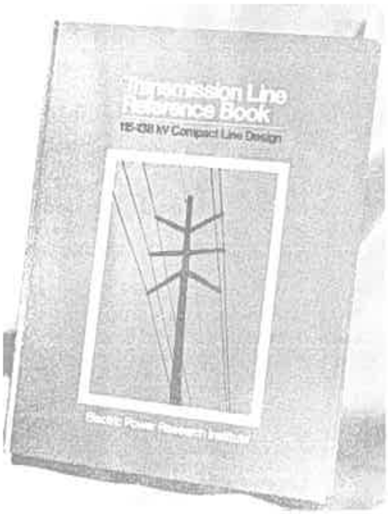
Among the several other firms occupying the Center is a service company which operates a fully equipped machine shop and a metal fabrication shop. Also offered are field crews with a variety of heavy construction equipment. The service company mans the site at all times.

REPRESENTATIVE PROJECTS (1972-present)

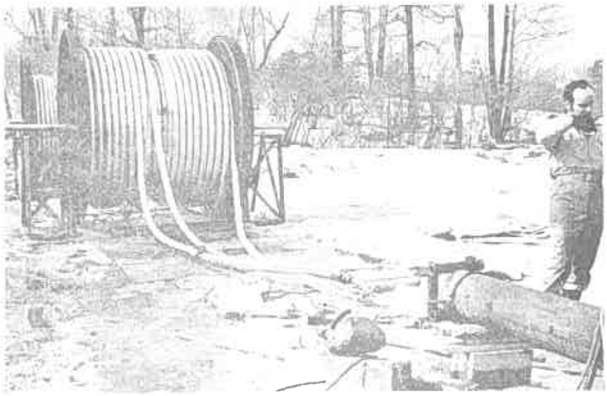
- Investigations into the development of technology for increasing the efficiency of power transmission achievable with both overhead and underground circuits were conducted under contract to New York State Energy R&D Authority (NYSERDA). Work included minimizing the environmental intrusion of overhead power lines and quantifying the possible rating increases on oil-filled pipe cables by using forced cooling. A one-half mile, 138 kV, experimental overhead transmission line with three-foot phase spacing was constructed, energized, and subjected to extensive testing. A 600-foot High Pressure Oil Filled (HPOF) pipe cable was installed to test full-size 345 kV cables under static and forced cooling conditions.

REPRESENTATIVE PROJECTS (continued)

o Development of a compact 115-138 kV transmission line design was sponsored by the Electric Power Research Institute (EPRI). The project included construction of a one-quarter mile multiconfiguration line for full-scale tests on various line arrangements, a ground level span for conductor ice shedding and fault current tests, and an elevated long span for tests on wind induced conductor motion. Tests were also made on radio noise, audible noise, and electrostatic fields. Results of this project have been published as a design handbook entitled, Transmission Line Reference Book: 115-138 kV Compact Line Design, (EPRI-1978).

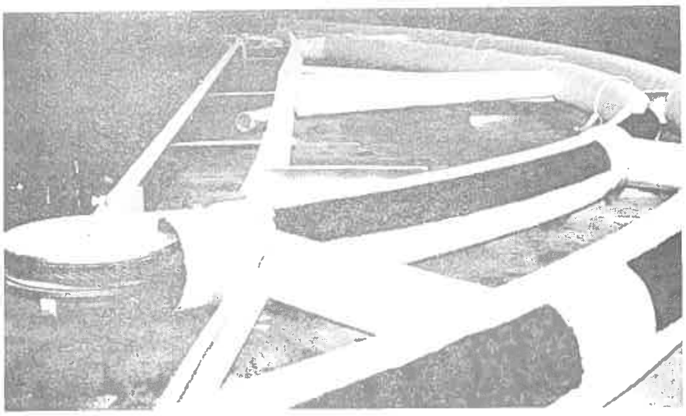


Compact Line Results


HPOF Cable Installation

o Research on the forced cooling of underground HPOF pipe cable systems at 230 kV and 345 kV was conducted for New York State Energy Research and Development Authority. A second 600-foot HPOF pipe cable was installed with extensive instrumentation and data acquisition capabilities. A 4000 ampere dc current supply was used to heat the 600-foot pipe cable installations. Detailed design information was obtained concerning thermal and hydraulic parameters associated with pipe type cable systems.


Pressure Monitoring During Power Up

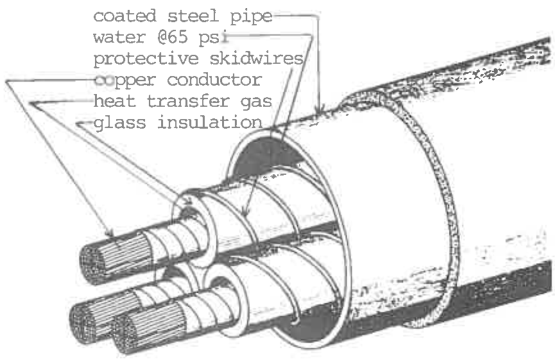

Sidewall Pressure Test Bed

o An evaluation of the effects of mechanical forces during installation on the insulation of underground pipe cables was sponsored by EPRI. Facilities were constructed to conduct coefficient of friction and sidewall pressure tests on pipe type cables ranging from 138 kV through 345 kV. Tensile and elongation tests on copper and aluminum conductor cables were made over the size range of modern application. Data was used to update the data which dictate cable installation and construction practices.

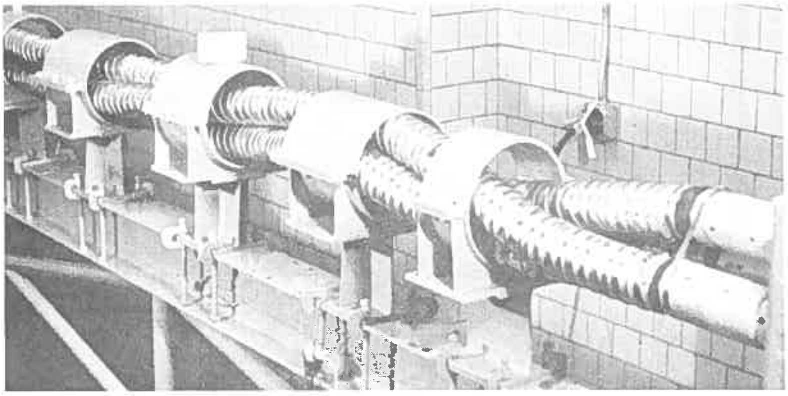
o Test site facilities are used in cable and splice failure analyses over a broad range of cable types and ratings, on utility, industrial and commercial installations. Clientele have included both manufacturers and users.

REPRESENTATIVE PROJECTS (continued)

o An investigation of the thermo-mechanical bending behavior of pipe type cables is being co-sponsored by EPRI and the Empire State Electric Energy Research Company (ESEERCO). Theoretical analysis and experimentation is being undertaken to establish a better understanding of EHV pipe type cable behavior in response to thermal cycling. The project is to determine relationships between cable construction variables and failure mechanisms and includes designing and full scale testing cables of improved integrity.



Glass Insulated Pipe Cable

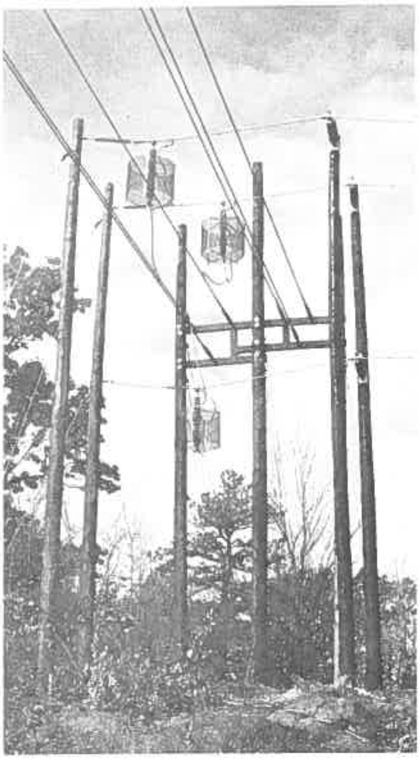


Thermo-Mechanical Cable Test Apparatus

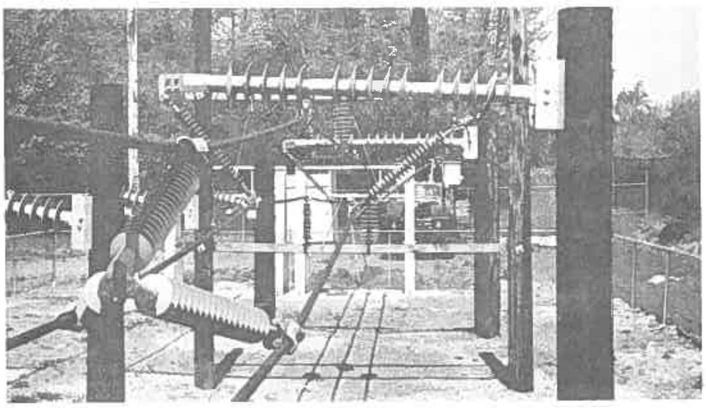
o Evaluation of a novel underground transmission system using a glass insulation medium was undertaken under contract from the U.S. Department of Energy. The system was tested for both electrical and mechanical performance. The project included the use of an indoor high voltage test bay.

o An investigation into the wind motion characteristics of a novel conductor design was performed for Kaiser Aluminum Co. The 860-foot long elevated overhead span was utilized and wind speed and conductor blowout was recorded.

o Development of bundled circuit transmission line designs was sponsored by EPRI to extend compact line design work. Applications of new insulator technologies were investigated to allow further increases in rights-of-way utilization efficiency. A double-circuit 1200-foot span was constructed, with circuits at two-foot and three-foot phase spacing. A 500-foot ground level span was also utilized to study complex conductor motions of spans with midspan spacers. Substantial substation expansion included a new test facility to study covered conductor operating at 138 kV.

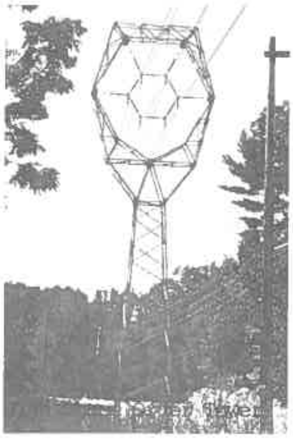


Bundled Circuits Terminal Structure with RI Filters



Covered Conductor Test Area

REPRESENTATIVE PROJECTS (continued)



- Appraisal of fast, accurate and reliable methods for location of gas or oil leaks in underground cable systems is being funded by EPRI. A full-size pipe cable joint casing has been built to observe oil flow patterns through the casing at various leak rates. A 55-foot length of buried cable pipe is to be used for controlled leak tests. Planned testing includes use of ground penetration radar, canine detection, tracer gas, flow indicators, and infrared scan testing.

- Formulation of an analytical model of distribution system, high impedance faults is the purpose of an EPRI-funded research program. High impedance distribution system faults are staged and instrumented to provide background data for quantification of the phenomenon. Results of this project may be used to determine ways to successfully detect faults of this nature.

- Development of data relating to the transmission of power using more than the conventional three phases is being funded by the U.S. Department of Energy. Both technical and economic factors of high phase order transmission are being analyzed. Conductor support structures, insulators, and spacers are being developed and both six-phase and twelve-phase experimental lines will be constructed.

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III. COMPUTER PROGRAMS

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PROGRAM PRODUCTS

The PTI family of program products for power system analysis is shown in Figure 1. This family is a subset of frequently-used members of PTI's program library that have been specially packaged and re-organized for use by electric utility engineers. It includes the following principal programs:

- PSS/E - A large scale interactive program for load flow, dynamic simulation, fault analysis, equivalent construction, and data base management.
- PCAP - Automatic transmission contingency analysis and security checking program.
- IPC - Interactive Production Costing Program.
- TPLAN - Interactive Transmission Expansion Planning
- RAP - Relay Analysis Program.
- LSAP - Linear Dynamics Analysis Program.
- TMLC - Transmission Line Constants Program.
- MNT/3 - Machine and Network Transients Simulation Program.

PSS/E is the heart of the system in that it provides the base case load flow needed as the starting point for most transmission system analyses. The other programs of the family are linked to PSS/E wherever appropriate for the exchange of transmission system, loading, or system, performance data. The PCAP Program may be operated independently of PSS/E. PSS/E is a prerequisite for programs such as MNT/3 and LSAP that require a load flow solution as input data. The IPC program is normally used independently.

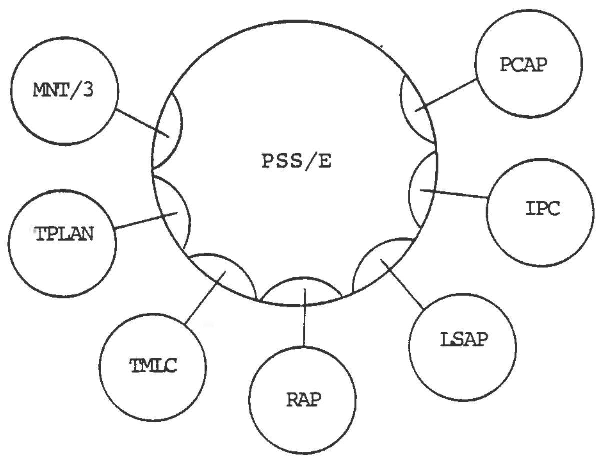

FIGURE 1

PROVEN APPLICATION AT PTI

This family of programs includes many of the basic computational tools used in PTI's own consulting engineering work. It is being developed and expanded constantly both to meet new engineering problem requirements and to improve its efficiency.

These program products are similar to all other PTI programs in that they embody only problem formulations and solution techniques that meet the exacting standards of the company's consulting engineering work. They differ from conventional programs principally in the degree of development of their interactive interfaces, bulk data input facilities, and automated linkages between one another.

New developments are released with these program products only after they have been tested and proved in production use by PTI engineers.

COMPUTER EQUIPMENT

These programs are designed to:

- Provide full interactive operation wherever appropriate.
- Be flexible with regard to user work station equipment so that new CRT console, printer, and graphics devices can be adopted without requiring major program modifications.
- Take full advantage of computer equipment that is optimized for scientific "number crunching" work.

The standard host computer system for these programs is the PRIME 400 CPU and its PRIMOS IV operating system. The PRIME CPU and PRIMOS have been proved in many installations of PSS/E, both at PTI and in electric utility offices. All members of this program family take full advantage of the advanced virtual memory, output spooling, time-sharing, and file management capabilities of the PRIME hardware and software.

All program input and output interfaces are based on ASCII-standard data transmission and on RS-232-C terminal data port connections. This allows the user to select his work-station equipment from a wide variety of CRT-consoles, high speed typewriter and plotter products, and to adopt new devices with a minimum impact on the programs.

DIALOG AND GRAPHICS

All programs are designed to be operated from simple text-only CRT or high-speed typewriter terminals. Control input is either by conversational dialogue or by editing of a data file, as appropriate in each individual application. Output reports may be displayed at the user work station, spooled in printed form, or retained in disc files for later disposition. The standard mass input/output unit is 9-track IBM-compatible magnetic tape.

Graphic outputs are standard features of several of the programs. The standard graphic output units are an electrostatic printer-plotter and a four-color pen-plotter.

INDUSTRY STANDARD INTERFACES

Programs in this family use industry standard data formats whenever possible. The preferred input format for PSS/E, for example, is the "IEEE Common Format for Exchange of Solved Load Flows."

PROGRAM DETAILS

Each program product and its application is described in detail by PTI bulletins, IEEE papers, and technical memoranda. Key program features and primary references are listed in Table I.

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12/79

TABLE I

PRINCIPAL PROGRAM DATA

PROGRAM	KEY CHARACTERISTICS	REFERENCE BULLETIN
PSS/E	4000 bus full detail load flow, fault analysis, electromechanical dynamics.	PTI/91
IPC	Probabilistic production costing with weekly or monthly time intervals for up to 150 thermal units and ten hydro and/or storage plants.	PTI/99
PCAP	Automatic contingency selection, evaluation, and security checking with automatic corrective redispatch and recognition of outage probability data. Up to 1500 buses.	PTI/78
TMLC	Transmission line constant calculation for up to eight coupled circuits.	PTI/104
LSAP	Linear dynamics analysis on basis of system A matrix as constructed by PSS/E.	PTI/105
RAP	Analysis of relay input signals as provided by PSS/E to guide engineer in relay setting.	PTI/106
MNT/3	Dynamic simulation with network modeled at individual phase differential equation level of detail. Machine modeling fully compatible with PSS/E. Up to 100 buses.	PTI/92

POWER TECHNOLOGIES INC

PSS/E
INTERACTIVE SIMULATOR FOR ENGINEERING AND PLANNING

BULLETIN PTI/91

P.O. BOX 1058 SCHENECTADY, NEW YORK 12301 518 374-1220

PSS/E is a 4000 bus fully interactive power system simulation facility. It provides utility planning and design engineers with advanced capabilities for:

Load Flow - with d.c. transmission, multiple generators at a bus, adjustable load-voltage characteristics, and planning level economic dispatch.

Stability/Dynamic Simulation - including highly detailed machine, nonlinear load, relay, d.c. transmission, and supplementary controls modeling.

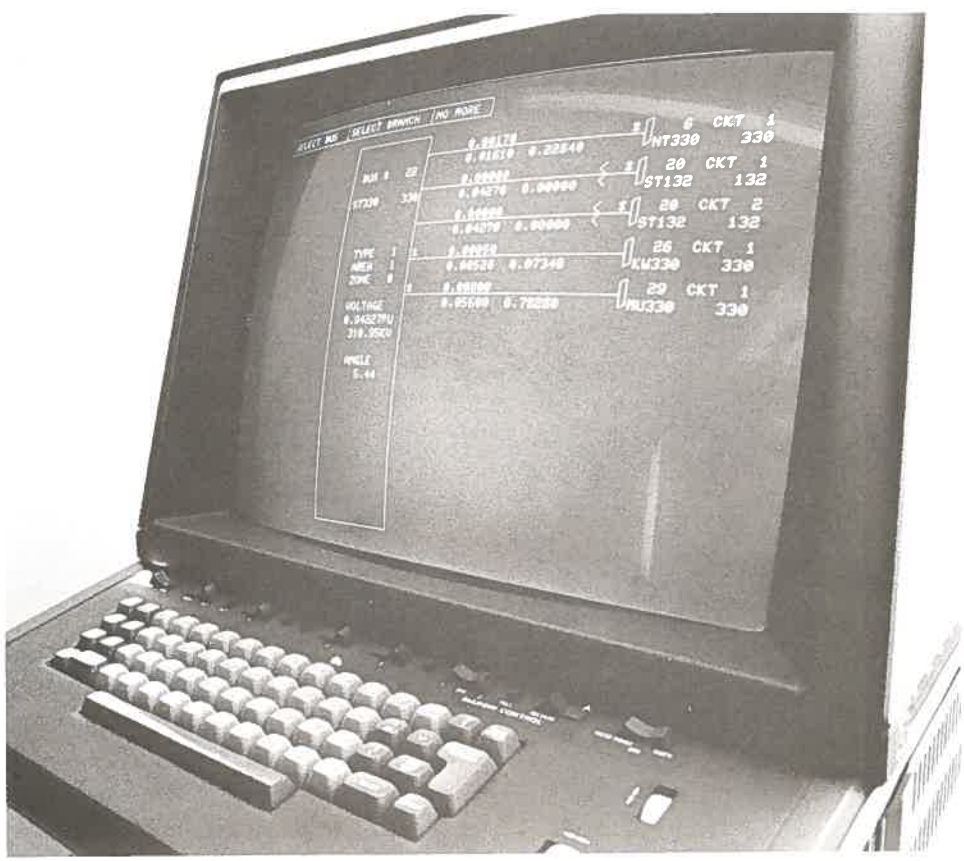
Short Circuit - balanced and unbalanced, allowing simultaneous unbalanced faults.

Equivalent Construction - for load flow and dynamic simulation, and fault analysis.

Working Data Base Maintenance - by complete integration of all processing functions with a common problem-oriented library of "cases" including load flow, dynamics and fault data.

Graphic Display - of data and results on hard copy and CRT units. Displays include load flow one-line diagrams, dynamic simulation plots, and bus data summaries.

PSS/E is designed for use in modern computers dedicated to the power system engineering application.



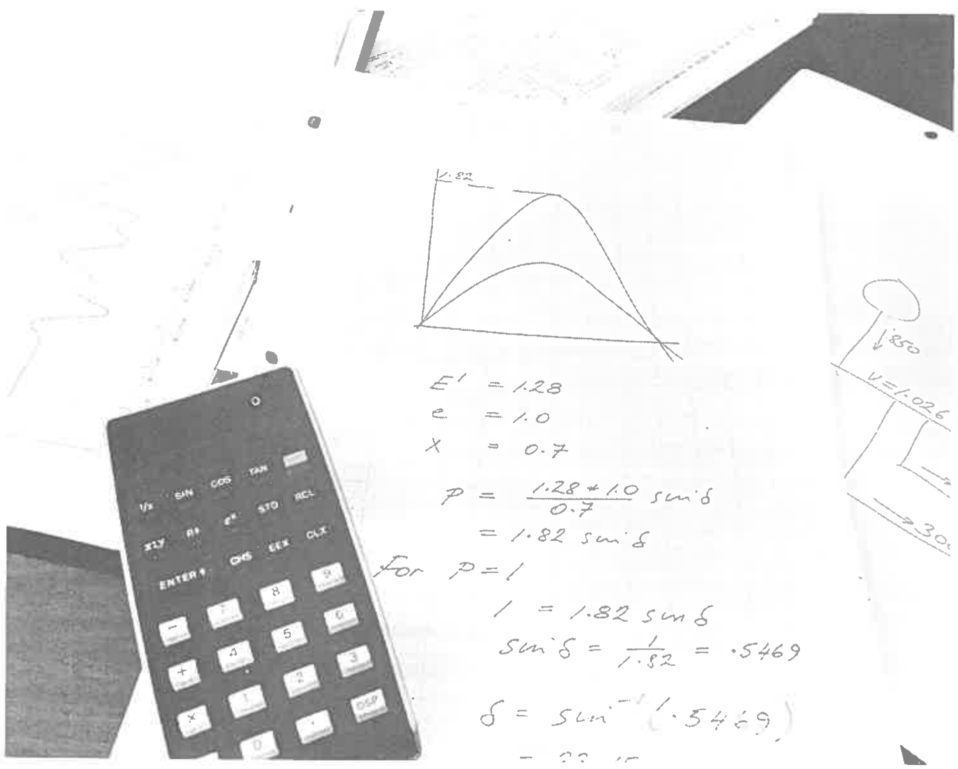
PSS/E is optimized for application in power system planning and engineering where variety in the type of problem and equipment that can be considered is of paramount importance. PSS/E is not intended for use as an on-line program; it is complemented by an independent program system (PSS/O) which is designed for that application.

PSS/E is currently in service in more than 30 utilities in the U.S.A., Canada, and Scandinavia.

OPERATION OF PSS/E

The Calculator Principle

The operation of PSS/E is similar in principle to that of an advanced hand-held calculator. With the calculator, the user places a number in the display register and presses function keys to perform operations on this number. The intelligence needed to select the number and keystroke sequence is provided by the user; the processing power is provided by the calculator. In the case of PSS/E, the "display register" is replaced by a large working file containing a complete positive-negative-zero sequence and dynamics representation of the user's power system; the mathematical functions (keys) of the calculator are replaced by power system analyses functions such as "iterate load flow," "advance time simulation," or "summarize line overloads."



The engineer using PSS/E communicates with it by question-and-answer dialogue through a CRT-keyboard terminal. The program displays instructions, lists of options, and questions to the user, who responds by typing brief commands and data values.

Program Structure

The program is structured as a set of ACTIVITIES which may be invoked by command of the user to perform processing or I/O operations on a WORKING FILE of system data. The working file is used for all processing, and is backed up by an extensive data file library system which allows for storage and/or retrieval of multiple system representations, solved cases, and output listings.

PSS/E has two principal modes of control:

Full Interactive Mode

On initiation the master program module of PSS/E invites the user to specify the first activity to be executed and immediately transfers control to that activity. When any activity is terminated, whether by completion, by user interruption, or by an abnormal condition, control is returned to the master program module which immediately invites the user to select the next activity. Each activity carries on its own dialogue with the user through the CRT console, may read input data from data storage files or from the console, and may generate tabular and/or graphic output at the CRT console, in a file, or on a printing device.

Batch Mode

PSS/E may be used in batch mode for routine production runs. Batch runs are specified by a control language in which the user describes the run in a set of English-like sentences. The following example specifies a stability run in which a faulted line is to be tripped, reclosed into the fault, and then tripped and locked out.

```
RECOVER initial conditions FROM #SNAP AND #CVLF

INITIALIZE OUTPUT=#GOP,

 RUN to 0. SECONDS, PRINT=2, PLOT=2

  APPLY FAULT at BUS 154 with Z=15.,0. OHMS, BASEKV=230

   RUN to 5 CYCLES, PRINT=1, PLOT=1

    CLEAR FAULT at bus 154

    OPEN LINE FROM BUS 154 TO BUS 153, CIRCUIT 2

     RUN to 35 CYCLES, PRINT=15, PLOT=3

      RECLOSE LINE FROM BUS 154 TO BUS 153, CIRCUIT 2

      APPLY FAULT at BUS 154 with Z=15.,0. OHMS, BASEKV=230

       RUN to 40 CYCLES, PRINT=1, PLOT=1

        CLEAR FAULT at bus 154

        OPEN LINE FROM BUS 154 TO BUS 153, CIRCUIT 2

        CHANGE MWI LOAD on BUS 153 TO 110. MW

        CHANGE MVARB LOAD on BUS 153 TO -50. MVAR

         RUN to 4 SECONDS,

 HOLD end run conditions in #SNER AND #SCER

 END
```

The PSS/E executive has an internal macro-scheduling capability which allows routine job steps to be handled in batch mode while critical setup and decision-making steps are executed in interactive mode with the engineer taking full control.

HARD COPY GRAPHICS

While PSS/E may be operated in a minimum configuration computer system having only text input/output devices, the standard PSS/E package includes activities for hard-copy graphic operation.

The graphical outputs of the standard PSS/E package include:

> Load flow one-line diagrams showing voltages, branch flows, load equipment status, and element impedances.
>
> Plotting of dynamic simulation results in a variety of formats with provision for comparison of the results of several simulation runs on a single plot.

Hard-copy graphic outputs may be produced by a Versatec electrostatic printer/plotter located at the CPU or by pen-plotters located at work stations.

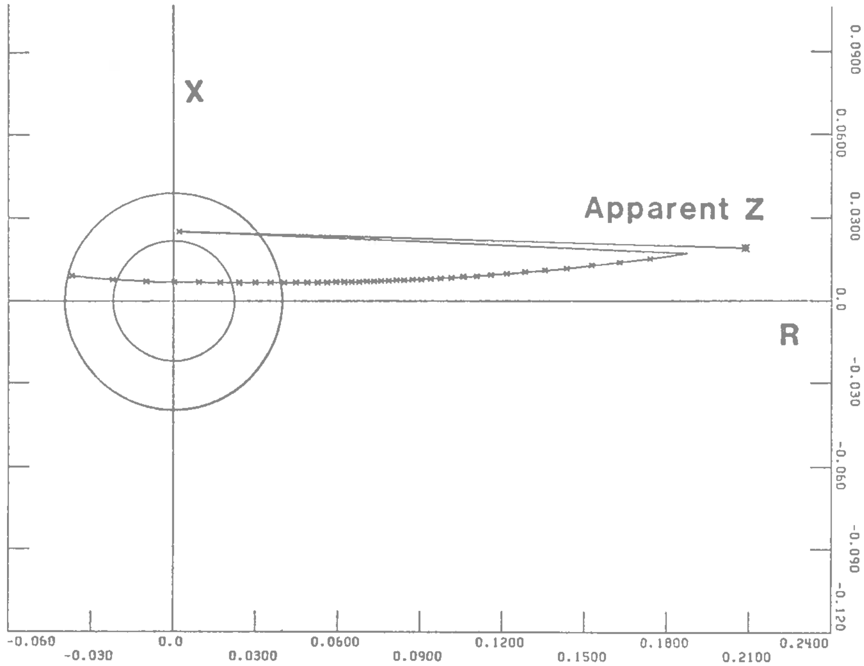
USER DIALOG

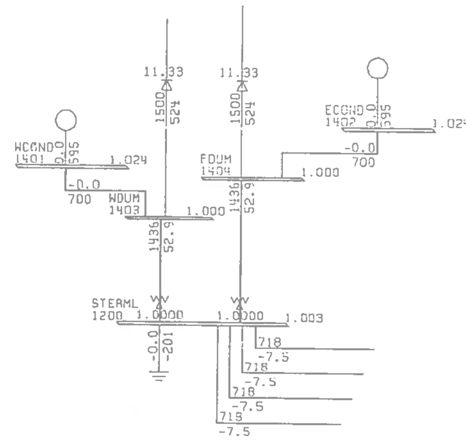
The basic PSS/E system handles all of its interactive operator communication through a simple text-only CRT console. All program communications with the user are English language text messages, and all user inputs are typed on the standard typewriter keyboard.

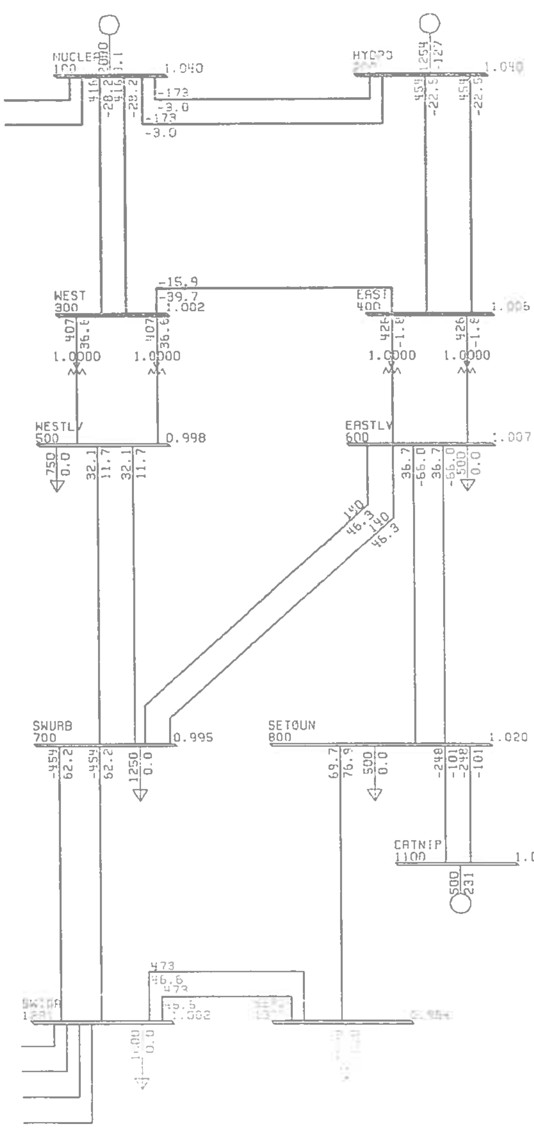
The choice of this mode of interaction is based on more than 25 engineer-years of hands-on interactive computing at PTI. It has several key advantages:

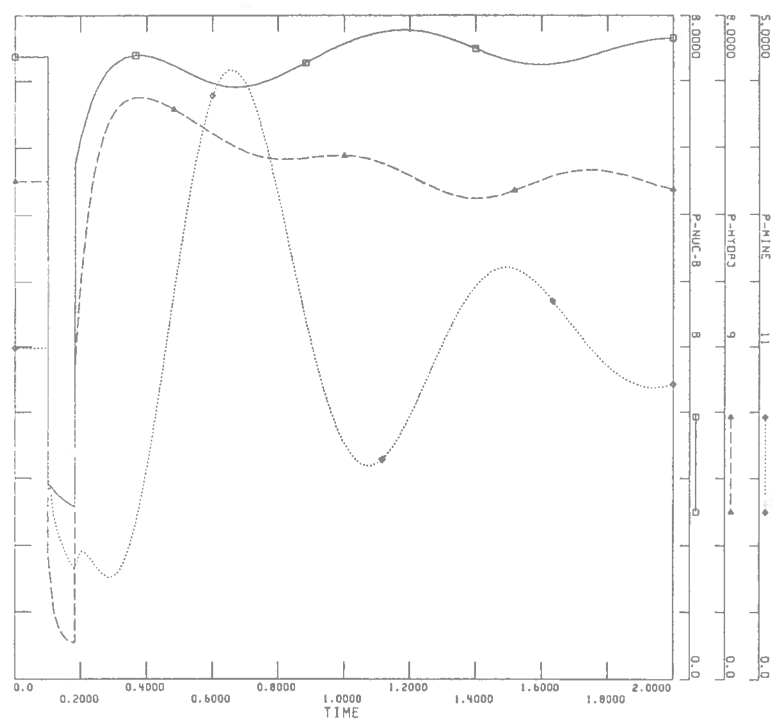
> It involves the minimum equipment cost and hence allows the user to obtain the full benefits of interactive working with a minimum initial investment.
>
> This form of dialogue may readily be switched from the CRT to a typewriter unit for back-up or when a hard copy of an interactive session is required.

The basic CRT work stations may be augmented by a wide variety of graphic CRT, printing, and pen-plotting units at the user's option.


X
Apparent Z
R
-0.060
-0.030
0.0
0.0300
0.0600
0.0900
0.1200
0.1500
0.1800
0.2100
0.2400


WCOND
1401
ECOND
1402
FDUM
1404
WDUM
1403
STEAML
1200


NUCLEAR
100
HYDRO
WEST
300
EAST
400
WESTLV
500
EASTLV
600
SWURB
700
SETOWN
800
CATNIP
1100


TIME
P-NUC-B
P-HYDRO
P-MINE

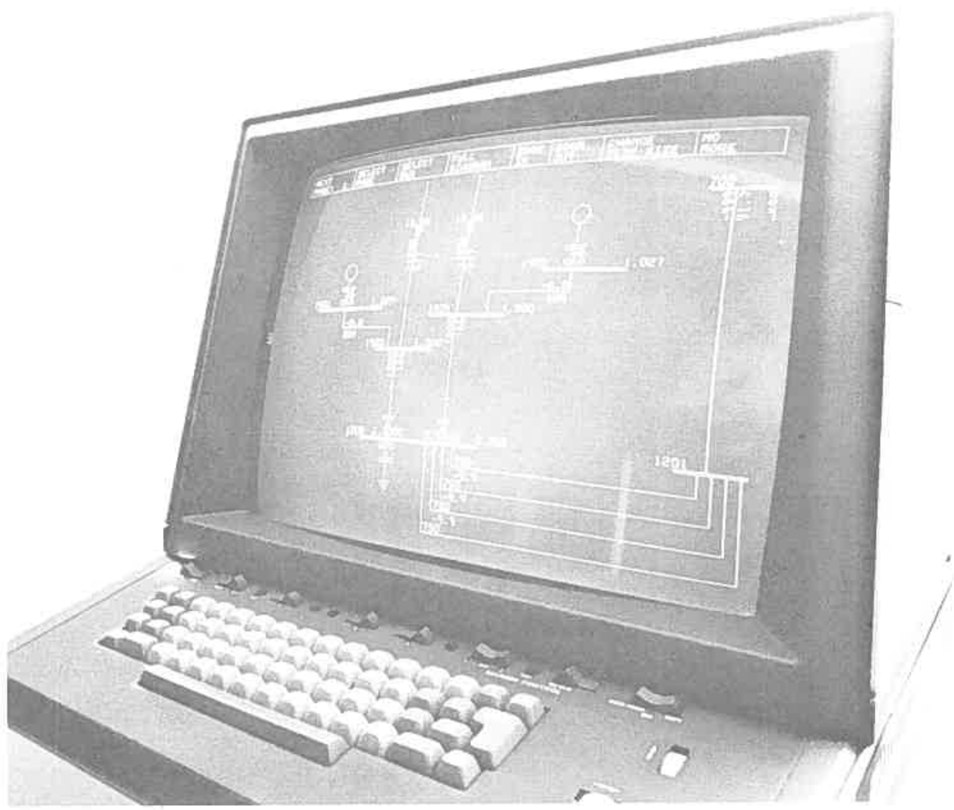
CRT GRAPHICS

An enhancement package may be added to the basic PSS/E package to provide CRT-graphic facilities. The CRT-graphic capabilities include symbolic display and manipulation of load flow data and previewing of dynamics output plots. As with normal text-style dialog, the CRT-graphics section of can use a wide range of terminals of varying price and sophistication. This makes it practical to provide multiple graphic work stations at very reasonable cost.

CRT WORK STATION GRAPHICS

Functions

The CRT graphic subsystem complements the hard-copy graphics functions of the basic PSS/E package. It allows the user of PSS/E to display load flow results and dynamic simulation plots at a CRT work station. The CRT displays have the same format as the standard hard-copy graphic outputs of PSS/E, with the added capability to zoom in on areas of specific interest. The CRT graphic subsystem also provides a graphic-based data examination and change facility. Page 1 shows a sample CRT one-line diagram display and this page shows a sample display of the graphic data examination/change activity.



Equipment

The CRT Graphic Subsystem is designed for a Tektronix 4014-1 Cathode Ray Tube console. Tektronix units with lesser capabilities, such as the Tektronix 4010, or the Lear-Seigler ADM-3/Retro-graphics terminal may also be used where cost is to be minimized. The Tektronix 4014-1 CRT should include options 01, 30, and 34, and the user should obtain the Plot-10 software driver package (part No. A4010A01) from Tektronix before installation of the PSS/E CRT graphics subsystem. The Tektronix CRT may be augmented by a Tektronix 4361 thermal hard-copy unit. This is connected directly to the CRT and provides very fast direct copies of significant CRT displays.

High quality hard-copy graphic output may be obtained on Tektronix 4662 or 4663 pen plotters. These may be connected in series with the CRT work station (not necessarily a Tektronix CRT), or may be used for spooled graphic output on a separate line from the asynchronous multiplexer of the computer. CRT graphic terminals should be operated at 9600 baud.

Graphic Interaction

Interaction between CRT displays and the user is via the cursor or crosshairs of the CRT. The cursor/crosshairs may be used to:

- Direct the load flow display to zoom in on a specific point.
- Select display options from a menu.
- Direct the data examination/change function to a specific bus or branch.

The load flow output and dynamics plotting CRT graphic activities allow immediate "redrawing" of the display on the hard-copy device. This allows the user to "experiment" with the scaling of plots at the CRT and then commit his favored results to permanent form with a minimum of commands to the computer.

SELECTIVE REPORTING

PSS/E allows the user a broad range of options in manipulating his system data. Dialog may be carried on in terms of either bus numbers (at random between 1 and 9997), or bus names (eight characters plus four-digit base voltage field). Output reports may be ordered either numerically or alphabetically.

All system manipulation operations and reporting activities may work selectively. The selection criteria are area, zone, base voltage level, and range-of-bus number. A user can, for example, request an output report for buses in areas 7 through 9 at voltages above 230 kV, or perhaps, examine overloads on all lines at 230 kV and above but ignore overloads in lower voltage circuits.

PROGRAM FEATURES

The standard capacity limits of PSS/E are presently as follows:

ELEMENTS	MAXIMUM CAPACITY
Buses	4000
Branches	8000
Generators	1200
Transformers	1600
Interchange Areas	100
Loss Zones	999
DC Transmission Links	20

The advanced capabilities of PSS/E do not stop at the interactive interface; rather PSS/E embodies PTI's philosophy that interactive working is the most advantageous way of using advanced and detailed system modeling methods. Accordingly, PSS/E includes a comprehensive array of advanced system modeling and calculation techniques in all of its activities. Some of the salient features are:

Load Flow

Solution by Gauss Seidel, Newton-Raphson, decoupled Newton, or secondary adjusted Gauss Seidel iteration.

User may switch between iteration methods at any point in the solution.

Selectable automatic adjustment of transformer ratio (voltage control), phase shift (power control), and area interchange; remote-bus voltage regulation by both transformers and generators.

Hard copy one-line diagram output format.

Simple unit commitment and economic dispatch to establish generation situation.

Adjustment of loads in an area, zone, or voltage level by user-specified ratios.

Automatic checking and summarization of line, transformer, and generator overloads.

Short Circuit

Solution giving all phase and sequence quantities for any bus or branch.

Simultaneous application of unbalanced faults at any network location on any phase.

Faults located at any point along a line, including line end faults.

Exact treatment of delta-wye transformer phase shift.

Multiple mutually coupled lines on a common right-of-way.

Automatic recognition of transformer type in sequence network setup.

Dynamic Simulation

Selectable machine models including solid rotor and salient pole representations at subtransient level, classical model, and provision for additional user-written models.

Comprehensive library of excitation system, turbine-governor, stabilizer, and other control models.

Load model library allowing loads to be modeled as a function of bus voltage and local bus frequency.

Relay models may switch network branches, disconnect loads, and trip generators.

User may add models to machine, control, and load model libraries.

Frequency dependence of all machine and network parameters is represented.

Detailed induction motor model valid from standstill to rated load.

Equivalent Construction

Load flow equivalents by network reduction from solved load flow case.

Simultaneous reduction of all three sequence networks for fault analysis equivalents.

INDUSTRY STANDARD DATA INTERFACES

PSS/E can accept load flow input data in several formats that are widely recognized by utilities in the U.S.A. The preferred input medium for load flow data is nine-track magnetic tape in one of the following formats:

- IEEE Common Format
- Philadelphia Electric Load Flow Format
- PSS/E Format

PSS/E can produce load flow tapes in each of these formats for transmitting data to other computers.

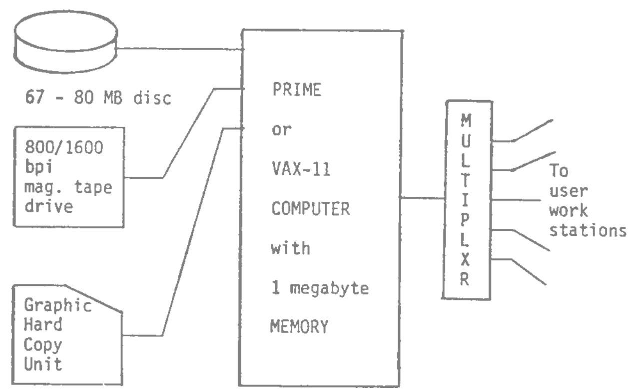
While there is not yet any widely used standard for dynamic simulation and fault-analysis data, special interfaces can be provided to allow PSS/E to accept this data from other programs.

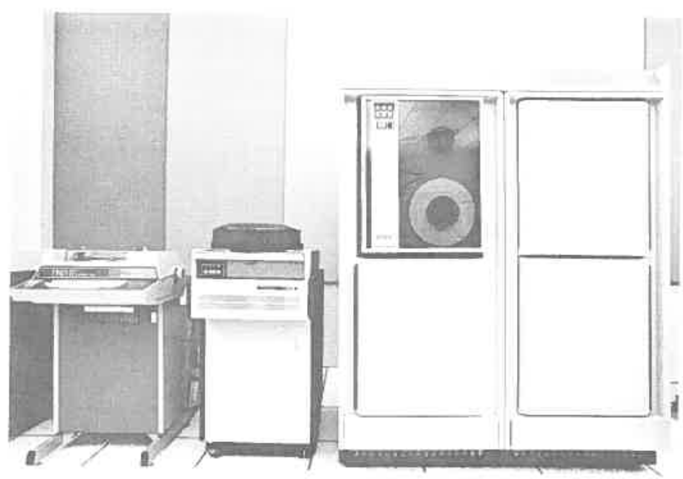
COMPUTER EQUIPMENT

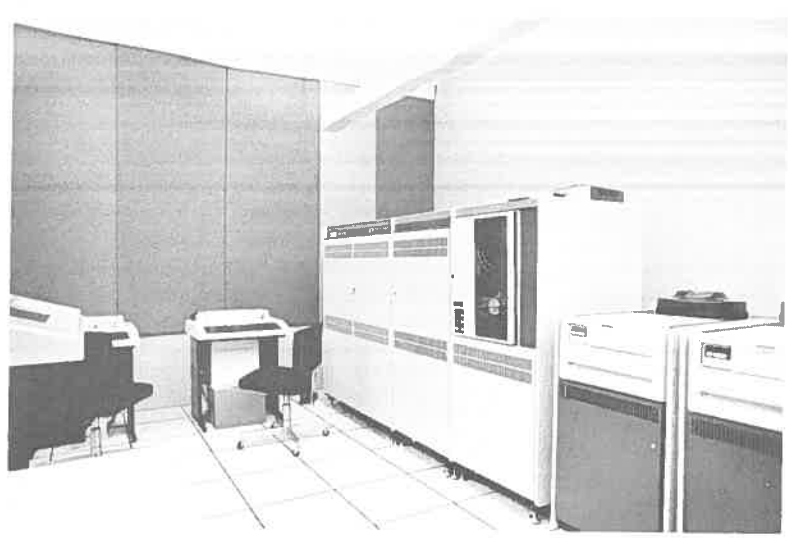
CPU and Operating System

The PSS/E system operates on PRIME and Digital Equipment Corporation's VAX-11 computers. The minimum equipment configuration for PSS/E is shown below. This minimum configuration allows as many as four engineers to work simultaneously on problems in the 1000 bus size range. Larger equipment configurations allow a single CPU to service, for example, three users working simultaneously on problems in the 2500 bus size range.

PSS/E resides within the standard operating system of the host computer.







Bulk Input-Output

The nine track 800/1600 bpi magnetic tape drive provides bulk data linkage with other computers. It may be used, via standard utility routines, for backup of disc files, transfer of output files to microfiche facilities, and exchange of load flow cases between utilities. Both ASCII and EBCDIC character sets may be used.

High volume printed output and graphic output are handled by an electrostatic or pen-type plotter unit. A line printer is normally provided to handle bulk output requirements.

Communication

All communication between the CPU and the work stations uses the ASCII character set and RS232 interfaces. The standard multiplexer allows up to 15 work stations to operate at individually selected rates between 30 and 960 characters/second.

Work stations can be direct-wired if located within 300 meters of the CPU. Remote work stations are handled via 1200 baud modems and dial up or dedicated voice-grade telephone circuits.

Disc

The single minimum disc memory specified for PSS/E can accommodate a basic library of load flow saved cases and dynamic simulation snapshots. Additional discs may be needed depending on users' data library needs and can be connected to the system as required.

Work Stations

Since the electrostatic printer/plotter unit provides both hard copy printing and graphic output, but must be located close to the CPU, PSS/E allows the user to establish:

- CRT units alone at work stations close to the CPU site, where the engineer can get hard-copy immediately from the electrostatic unit.
- CRT/Printer/Pen-Plotter combinations at work stations not having convenient immediate access to the CPU and electrostatic unit. Such work stations might, for example, be on different floors from the CPU, or even in different buildings.

<u>TRAINING AND SUPPORT</u>

The PSS/E package includes installation and training by PTI as follows:

- Installation and testing of the PSS/E system in the user's computer.
- A five day training seminar for user engineers and programmers at the user's offices.

The PSS/E package includes the following reference material:

- o Program Application Manual giving details of program capabilities, engineering aspects of its use and data setting requirements.
- o Program Operations Manual giving details of input formats, console procedures and error conditions.
- o Data Exchange Manual to allow external utility sources to prepare data for PSS/E users.

The PSS/E system can be supplied by PTI either as an all inclusive system of hardware and software, or as a package of programs for installation on an independently obtained computer of suitable specification. PTI can assist in tailoring a computer specification to meet specific needs.

<u>FOR FURTHER INFORMATION</u>

Contact: Dr. John Undrill, Principal Engineer
Power Technologies, Inc.
P.O. Box 1058
Schenectady, New York 12301

Tel. (518)374-1220
Telex 145498 POWER TECH SCH

IV. CLIENT LIST

POWER TECHNOLOGIES INC	LIST OF CLIENTS	BULLETIN PTI/21 Page 1 of 4
P.O. BOX 1058	SCHENECTADY, NEW YORK 12301	518 374-1220

Clients are listed below by name, location and business only. Where additional information is desired, PTI will request clearance of the client company to release such information, or will aid in establishing direct reference.

ELECTRIC UTILITIES

Domestic

- o Allegheny Power Service Corp.
- o American Electric Power Service Corp.
- o Arizona Public Service Co.
- o Baltimore Gas & Electric Co.
- o Basin Electric Power Co-op.
- o Bonneville Power Administration
- o Boston Edison Co.
- o Central Maine Power Co.
- o Central & South West Corporation
- o Cincinnati Gas & Electric Co.
- o City of Tacoma
- o Consolidated Edison Co. of N.Y., Inc.
- o Consumers Power Co.
- o Cooperative Power Association
- o Dairyland Power Cooperative
- o Dayton Power & Light Company
- o Delmarva Power and Light Co.
- o Detroit Edison Co.
- o Florida Power & Light Co.
- o Florida Power Corporation
- o General Public Utilities, Inc.
- o Georgia Power Company
- o Gulf States Utilities
- o Hawaiian Electric Co.
- o Hoosier Energy Div. of Indiana Statewide Rural Electric Co-op.
- o Houston Lighting & Power Co.
- o Interstate Power Co.
- o Iowa Power & Light Co.
- o Jacksonville Electric Authority
- o Jersey Central Power & Light Co.
- o Kansas City Power & Light Co.
- o Long Island Lighting Co.
- o Los Angeles Dept. of Water & Power
- o Madison Gas & Electric
- o Middle South Utilities
- o Minnesota Power & Light Co.
- o Minnkota Power Cooperative
- o Montana-Dakota Utilities
- o Montana Power Company
- o Nebraska Public Power Dist.
- o NEGEA Service Corporation
- o New England Electric System
- o New York State Electric & Gas Corp.
- o Niagara Mohawk Power Corporation
- o Northeast Utilities Corp.
- o Northern States Power Co.
- o Omaha Public Power District
- o Orange & Rockland Utilities, Inc.
- o Otter Tail Power Co.
- o Pacific Power & Light Co.
- o Pennsylvania Power & Light Co.
- o Philadelphia Electric Co.

Foreign

- o Agua y Energia (Argentina)
- o British Columbia Hydro & Power Authority (Canada)
- o CADAFE (Venezuela)
- o Calgary Power (Canada)
- o CEMIG (Brazil)
- o CESP (Brazil)
- o Comision Federal de Electricidad (Mexico)
- o CHESF (Brazil)
- o EDELCA (Venezuela)
- o EDELCA (Venezuela)
- o Electricidad de Caracas (Venezuela)
- o Electricity Supply Comm. (S. Africa)
- o Electricity Comm. of Victoria (Australia)
- o ELETROSUL (Brazil)
- o Empresa de Energia Electrica de Bogota (Colombia)
- o Fuerzas Electricas de Cataluna (Spain)
- o FURNAS (Brazil)
- o Hidroelectrica Espanola (Spain)
- o Hidronor (Argentina)
- o Iberduero (Spain)
- o INECEL (Equador)
- o Luz y Fuerza (Mexico)
- o Manitoba Hydro (Canada)
- o New Brunswick Electric Power Commission (Canada)
- o New Zealand Electricity Department (New Zealand)
- o Norwegian State Power Board (Norway)
- o Nova Scotia Power Commission (Canada)
- o Ontario Hydo (Canada)
- o Quebec Hydro-Electric Comm. (Canada)
- o Rio and Sao Paulo Light (Brazil)
- o SEGBA (Argentina)
- o State Electricity Commission (West Australia)
- o Swedish State Power Board (Sweden)
- o SYDKRAFT (Sweden)
- o TAIPOWER (Taiwan)

Electric Utilities, continued

Domestic	Foreign

- o Portland General Electric Co.
- o Potomac Electric Power Co.
- o Public Service Electric & Gas Co. (N.J.)
- o Public Service Co. of Indiana
- o Public Service Co. of New Hampshire
- o Public Service Co. of New Mexico
- o Puget Sound Power & Light
- o Puerto Rico Electric Power Authority
- o Rochester Gas & Electric Corp.
- o Sacramento Municipal Utility Dist.
- o Salt River Power District
- o San Diego Gas & Electric Co.
- o Southern California Edison Co.
- o Southern Company Services
- o Southern Indiana Gas & Electric Co.
- o Tennessee Valley Authority
- o Toledo Edison Co.
- o UGI Corporation
- o Union Electric Co.
- o United Illuminating Co.
- o United Power Association
- o Utah Power & Light Co.
- o Virginia Electric & Power Co.
- o Washington Water Power Co.
- o Wisconsin Power & Light Co.

POWER POOLS

- o Mid-Continent Area Power Planners
- o New England Power Exchange
- o New York Power Pool
- o P-J-M Interconnection
- o Wisconsin-Upper Michigan Pool

- o GCOI (Brazil)
- o Krangede Power Pool (Sweden)
- o OPSIS (Venezuela)

INDUSTRIALS

- o AiResearch
- o Allied Chemical
- o Arabian American Oil Co.
- o Chemplex
- o Cities Service Co.
- o Consolidated Papers
- o Continental Oil Co.
- o DuPont
- o Exxon Enterprises
- o Exxon Research & Engineering
- o Fluor Utah
- o Fort Pitt Steel
- o Hess Oil Virgin Islands Corp.
- o Humble Oil Co.
- o IBM
- o Lockheed Missiles & Space Co.
- o Martin Marietta Aluminum
- o Union Carbide

- o Algoma Steel Corp (Canada)
- o TAMSA (Mexico)

MANUFACTURERS

- o ALCAN Cable Corporation
- o ALCOA
- o Anaconda Wire & Cable Company
- o Baker Automation
- o Bethea Company
- o Boeing Electronics
- o Ceramaseal, Inc.
- o Collyer Wire and Cable
- o Control Data Corporation

- o ASEA (Sweden)
- o CGEE Alsthom (France)
- o GEC Switchgear (England)
- o Nokia Electronics (Finland)
- o Pirelli (Italy)

Manufacturers, continued

Domestic

- o Environment One
- o Essex Group United Technologies
- o General Automation
- o General Electric Co.
- o Gould-Brown Boveri Corp.
- o Harris Controls
- o High Voltage Breakers, Inc.
- o High Voltage Power Corp.
- o Kaiser Aluminum Chemical Corp.
- o Lapp Insulator, Interpace Corp.
- o McGraw-Edison Co.
- o Moore Systems
- o Owens-Illinois
- o Phelps Dodge
- o PRD Electronics
- o Prodelin, Inc.
- o Quindar Electronics
- o Sangamo Electric Co.
- o Simplex Wire and Cable
- o TRW Controls
- o 3M Company
- o Triangle Conduit and Cable
- o United Technologies
- o Westinghouse Electric Co.

Foreign

CONSULTANTS, ENGINEERS, CONSTRUCTORS

- o Booz Allen & Hamilton
- o Cannon Design
- o W.A. Chester, Inc.
- o Doble Engineering Co.
- o EBASCO Services, Inc.
- o F. Eberstadt & Co.
- o Forest Electric
- o Gibbs & Hill
- o Gilbert Associates
- o International Engineering
- o Kaiser Engineering, Inc.
- o Keane Associates
- o Arthur D. Little Co.
- o Chas. T. Main, Inc.
- o NUS Corporation
- o Douglas G. Peterson & Assoc., Inc.
- o Sargent & Lundy
- o S.M. Stoller Associates
- o Stone & Webster Engineering
- o Sverdrup & Parcel
- o United Engineers
- o Wismer & Becker

- o ACRES, Ltd. (Canada)
- o Constructeurs Inga-Shaba (Zaire)
- o Development Consultants (India)
- o Elmec, Ltda. (Colombia)
- o FERRCO (Canada)
- o Landis & Gyr (Switzerland)
- o Motor Columbus (Switzerland)
- o SADE/ESIN (Argentina)
- o SNC-Lavalin (Canada)
- o Techno Proyectos (Argentina)

OTHER

- o Aerospace Corporation
- o Arizona Corporation Commission
- o Brookhaven National Labs.
- o California Energy Resources Conservation and Development Commission
- o Corps of Engineers (U.S. Gov't)
- o Dept. of Energy (U.S. Gov't)
- o Electric Power Research Institute
- o Energy Research and Development Authority (N.Y. State)
- o Ford Foundation
- o Fusion Energy Corporation
- o Dept. of Interior - Bureau of Reclamation (U.S. Gov't)
- o Long Island Farm Bureau (N.Y. State)

- o CEPEL (Brazil)
- o ELTROBRAS (Brazil)

Other, continued

Domestic

- o Los Alamos Space Laboratory
- o NASA (U.S. Gov't)
- o Naval Research Labs (U.S. Gov't)
- o Northeast Power Coordinating Council
- o Power Authority of the State of N.Y.
- o Power Facility Evaluation Council (State of Connecticut)
- o Dept. of Public Service (N.Y. State)
- o Rand Corporation
- o Sandia Laboratories
- o The Hartford
- o Tulane University
- o University of California
- o University of Illinois
- o Worcester Polytechnic Institute

Foreign

FOR FURTHER INFORMATION

Contact: Lionel O. Barthold, President
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P.O. Box 1058
Schenectady, N.Y. 12301

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Telex 145498 POWER TECH SCH

V. SELECTED STAFF RESUMES

POWER TECHNOLOGIES, INC.
Biographical Summary

LIONEL O. BARTHOLD
President

Mr. Barthold holds a B.S. in Physics from Northwestern University (1950) where he was also elected to Phi Beta Kappa (Scholastic) and Pi Mu Epsilon (Mathematics) honorary fraternities. His General Electric career included a variety of assignments in Electric Power System Engineering, High Voltage Transmission Research, and in engineering management.

In 1959, Mr. Barthold was named Technical Director of G.E.'s Project Extra-High-Voltage, a 500 and 800 kV research center and test line in Pittsfield, Massachusetts. In 1968, he gained industry support for conversion of the site to an ultra-high-voltage research program and served on the project steering committee.

In 1963, Mr. Barthold was named Manager of G.E.'s A-C Transmission Engineering Operation in Schenectady. This section was responsible for equipment application, economic, and planning studies, a-c vs. d-c comparison studies, and a number of major system design projects.

He has authored over 50 technical articles in U.S. and International publications. Two of his papers were awarded first prize in the Power Group of IEEE.

Mr. Barthold established Power Technologies, Inc. in 1969 and serves as President and Chairman of the Board of Directors. He also serves on the Board of PTEL, the firm's Brazilian affiliate and is Chairman of the Board of the Technology Assessment Group, a consulting organization in which PTI holds an interest.

A registered Professional Engineer in New York State, he is a Fellow of IEEE and a member of CIGRE, the corresponding international society. Formerly a member of IEEE's Transmission and Distribution Committee and Chairman of a working group on Electrostatic and Electromagnetic Effects, he is presently a member of the Power Engineering Society's Administrative Committee and serves as vice president of that society. He has served as Chairman of the American National Standards Institute (ANSI) Committee 92, Insulation Coordination, and as U.S. delegate to the corresponding International Electrotechnical Commission (IEC) Committee. In 1976, he was named Chairman of a newly authorized CIGRE Study Committee 41 - Future of Electric Power Transmission and Systems.

Mr. Barthold was one of the organizers of the Energy for the Eighties Foundation and serves on the Board of Directors.

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TECHNICAL PAPERS AND ARTICLES AUTHORED AND CO-AUTHORED BY L.O. BARTHOLD

1. "Switching Surges and Arrester Performance on High-Voltage Stations," AIEE Transactions on Power Apparatus and Systems, Part III, Vol. 75, 1956, pp. 431-438. (Award: First Prize, 1956, National Power Division, AIEE.) (Co-authors, I.B. Johnson and A.J. Schultz).

2. "Approximate Transient Solution of the Tapered Transmission Line," Ibid., Vol. 76, 1957, pp. 1556-1561.

3. "Overvoltage Following Secondary Switching of Transformer Connected to High Voltage Lines," Ibid., Vol. 77, 1958, pp. 1492-1500, (co-authors, I.B. Johnson and A.J. Schultz).

4. "Response of a 345-kV Transmission Tower to a Simulated Lightning Stroke," IEEE CP59-275, (co-authors, I.R. Armstrong and A.J. Schultz).

5. "The Calculation of Attenuation Constants for Radio Noise Analysis of Overhead Lines," AIEE Transactions on Power Apparatus and Systems, Part III, Vol. 79, 1960, pp. 975-981 (co-author, G.E. Adams). (Award: Second Prize, 1960, Empire District Power Division, AIEE).

6. "Radio Frequency Propagation and Attenuation on the American Electric Power Dequine-Olive 345-kV Line," Ibid., Vol. 79, 1960, pp. 303-309, (co-authors, J.J. LaForest, R.H. Schlomann and F.J. Trebby).

7. "Model Techniques in the Transient Network Analyzer Solution of Power System Problems," Proceedings of the American Power Conference, Vol. XXII, 1960, pp. 722-731, (co-author, R.F. Silva).

8. "Digital Analysis of Traveling Waves," Proceedings of the American Power Conference, Vol. XXIII, 1961, pp. 932-940, (co-author, G.K. Carter).

9. "Digital Traveling Wave Solutions, Part I: Single-Phase Equivalent," AIEE Transactions on Power Apparatus and Systems, Vol. 80, 1961, pp. 941-947 (co-author, G.K. Carter). (Award: 1st Prize, 1961 National Power Div., AIEE).

10. "Digital Calculation of Radio Noise Levels," Ibid., 1961, pp. 312-320 (co-author, A.K. Abboushi). (Award: First Prize, 1961, Pittsfield Section, AIEE).

11. "Simplified Method for Determining Permissible Separation Between Arresters and Equipment," AIEE Working Group, AIEE Conference Paper 61-250, presented at the Winter General Meeting, New York, January 29 February 3, 1961 (co-authors, J.M. Clayton and J.D.M. Phelps).

12. "Selection of Single and Bundled Conductors and Accessories for Acceptable Radio Noise Performance," AIEE Conference Paper 61-1099, presented at the Fall General Meeting, Detroit, MI, October 15-20, 1961 (co-authors, J. Kaminski, J.J. LaForest, and H.E. House).

13. "Some Important Assumptions in the Calculation of Radio Noise Levels of EHV Lines," CIGRE Paper No. 303, 1962 (co-authors, R.S. Schlomann, and W.S. Price).

14. "Fault Arc Deionization and Circuit Breaker Reclosing on EHV Lines - Field, Laboratory, and Analytical Results," General Electric - American Electric Power Corp., Working Group Report, CIGRE Paper No. 307-1962.

15. "R.F. Propagation on Polyphase Lines," AIEE Transactions on Power Apparatus and Systems, Pt. III, Vol. 83, No. 7, 1964, pp. 665-671.

16. "The Significance of EHV Standards Around the World," Proceedings of the American Power Conference, Vol. XXXV, 1963. Reprinted in the Magazine of Standards, Dec. 1963, pp. 372-377 (co-author, E.M. Hunter).

17. "The Electrical Design of Future EHV Systems," Proceedings of the American Power Conference, Vol XXIV, 1962 (co-author, E.M. Hunter).

18. "500-kV Line Design - Part III - Conductors," IEEE Transactions on Power Apparatus and Systems, Vol. 82, No. 67, 1963, pp. 587-597, (co- authors, R.L. Thompson, J.J. LaForest, and C.B. Lindh).

19. "The Role of Statistics in EHV Line Design," Proceedings of the American Power Conference, Vol. XXVI, 1964, pp. 374-383, (co-authors, J.G. Anderson and E.M. Hunter).

20. "METIFOR — A Statistical Method for Insulation Design of EHV Lines," IEEE Transactions on Power Apparatus and Systems, Vol. 83, No. 3, 1964, pp. 271-280, (co-author, J.G. Anderson).

21. "Insulation Tests for the Design and Uprating of Wood-Pole Transmission Lines," (Committee Report), Ibid., Vol. PAS-85, No. 12, pp. 1258-67.

22. "High Voltage Power Transmission," Scientific American, May 1964, (co-author, H.G. Pfeiffer).

23. "Electrical Design of EHV Substations," Pacific Coast Electric Association, San Francisco, California, (co-author, J.B. Tice).

24. "Uprate Lines for Low-Cost Transmission Capacity," Transmission and Distribution, September, 1965.

25. "A Critical Review of Transmission Line Design Criteria," Pennsylvania Electric Association, Reading, PA, October 5-6, 1965.

26. "Planning and Design of the Venezuelan 400-kV System," CIGRE 1966, Paper 403, (co-authors, R. Telleria, A. Alazrachi, and J.M. Henderson).

27. "Transmission System Radio Influence," (Committee Report), IEEE Transactions on Power Apparatus and Systems, Vol. PAS-84, No. 8, 1965, pp. 714-724.

28. "Modern Analytical Methods -- Their Impact on Power System Planning and Design," Energy International, September, 1966, (co-author, L.K. Kirchmayer).

29. "Power Pooling," International Science and Technology, February 1966, (co-author L.K. Kirchmayer).

30. "Research in Extra-High-Voltage Transmission," Proceedings of the American Power Conference, 1967, Vol. 29.

31. "Maximize Right-of-Way Utilization," Electrical World's Third Energy Transportation Conference, Pittsburgh Hilton Hotel, Pittsburgh, PA, November 19-21, 1967.

32. "System Transmission Options Above 765-kV," Proceedings of the American Power Conference, 1968, Vol. 30, pp 1003-1009.

33. "Five-Year Research Program in Ultra-High-Voltage," CIGRE 1968, Paper No. 42-04, (co-author, P.L. Lumnitzer).

34. "Analytical Studies Reduce Risks of Uprating Transmission Lines," Electric Light and Power, May, 1968, (co-author, N.D. Reppen).

35. "Design Challenges of Transmission Lines Above 765 kV," EHV Transmission Conference, Montreal, September 30-October 2, 1968, (co-author, J.G. Anderson).

36. "How Soon Can Research Develop Economic UHV?" Electrical World, April 21, 1969, (co-author, J.G. Anderson).

37. "Probability Methods in Insulation Coordination," IEEE Summer Power Meeting, Los Angeles, 1970, (co-author, L. Paris), Conference Paper.

38. "The Influence of the Environment on System Growth Patterns," (co-authors, R.J. Ringlee and A.J. Wood), Public Utilities Fortnightly, November 25, 1971.

39. "Selection of Transmission Route Calls for Multi-discipline Approach," Electrical World, December 1, 1971, (co-author, Bruce Howlett).

40. "Environmental Factors in Siting of Transmission Facilities," presented at the American Public Power Association Engineering and Operations Workshop, Anaheim, CA, March 13-16, 1972.

41. "Options for Transmission System Planning in the 1980's," presented at the Electrical World's Executive Conference, "Meeting the Challenge of the 1980's," Hotel Shoreham, Washington, D.C., March 14-15, 1972.

42. "Outage Reporting - Definitions, Records and Applications," presented at the Doble Client Conference, March 1972, (co-author, R.J. Ringlee).

43. CIGRE Study Committee No. 31 - "High Phase Order Power Transmission," ELECTRA, Vol. No. 24, 1973, pp. 139-153, (co-author, H.C. Barnes).

44. "Impact of Computer Developments on Power System Research Needs," presented at the IEEE Conference on Research for the Electric Power Industry, December 11-14, 1972, Washington, D.C.

45. "Preliminary Reseach Studies on Compact Transmission Lines," IEEE Conference Paper CP C73-429-3, presented at IEEE Summer Power Meeting, Vancouver, B.C., July 15-20, 1973, (co-authors, I.S. Grant and V.J. Longo).

46. "Frontiers in Overhead Transmission Technology," presented at the Second National Seminar on Production and Transmission of Electric Energy, Belo Horizonte, Brazil, September, 1973.

47. "Electromagnetic Effects of Overhead Transmission Lines - Practical Problems, Safeguards, and Methods of Calculation," Paper T73-441-3, prepared by the Working Group on E/M and E/S Effects, presented at the IEEE Summer Meeting, Vancouver, B.C., July 15-20, 1973.

48. "Comparative Economic and Dynamic Studies of the Chicoasen Hydro Electric Plant," presented at MEXICON 76 IEEE Conference (co-authors, B.K. Johnson, R.E. Clayton, J.V. Landa, R.C. Guerrero, and V. Lescale).

49. "Public Assessment of Technical Industries -- The Electric Utility Dilemma," presented at the Second International Congress on Technology Assessment, Ann Arbor, MI, October, 1976.

50. "Compaction--A New Frontier in Transmission Research," presented at the 1977 PES Summer Power Meeting, (co-authors, D.D. Wilson and I.S. Grant).

51. "Modeling of Static Shunt Var Systems (SVS) for System Analysis," Working Group SC31, ELECTRA, No. 51, March, 1977, pp. 45-74.

52. "Software Products for Electric Power Systems," presented at the U.S. Commerce Dept.-sponsored East-West Trade Seminar, December, 1977.

53. "The Power Technology Course - An Example of the Consultant's Role in Continuing Education," IEEE Transactions on Education, Vol. E-21, August, 1978, pp. 166-169.

54. "The Power Factor of Power Educators," presented at the American Power Conference, Chicago, IL, April 23-25, 1979.

POWER TECHNOLOGIES, INC.
Biographical Summary

F.P. de MELLO
Principal Engineer
System Operation, Dynamics & Control

Mr. de Mello graduated with a B.Sc and M.Sc degrees in Electrical Engineering from MIT where he was elected to Tau Beta Pi and Sigma Xi. Having been enrolled in MIT's cooperative engineering program, his academic experience included several test engineering and laboratory assignments with the General Electric Co. between 1945 and 1948.

In 1948, he joined the Rio Light and Power Company in Brazil where he was given responsibility for studies of short circuits, stability, analysis of system interruptions, arrester application, capacitor application and relaying. He also held project management assignment in overhead and underground distribution.

In 1950, he was promoted to a staff assignment under the Assistant General Manager, Planning and Combined Operations of the Engineering Services Organization, serving the operating companies of the Brazilian Traction Light and Power Group. In this capacity, until 1955, he was responsible for power system planning and design studies concerning the future expansion of the Rio Light, Sao Paulo Light and City of Santos systems. Studies included the selection of electrical characteristics of generation and transmission facilities, considering factors such as operating requirements, insulation coordination, lightning arrester applications, switchgear application, transient stability, grounding and relaying.

In 1955, Mr. de Mello joined the Analytical Engineering Section of General Electric's Apparatus Sales Division. Here he undertook design and analysis studies of controls of industrial, power apparatus and aircraft power systems, making extensive use of analog computers.

In 1959, he was assigned to the General Electric Co. Electric Utility Engineering Operation where he specialized in studies of dynamics of electrical machines, excitation control, prime-mover systems and overall power systems.

From 1961 to 1969, he conducted and guided extensive research efforts on modeling of dynamics of power systems and power plants for use in advanced boiler and plant control design studies. Mr. de Mello made major pioneering contributions in the development of digital computer methods for dynamic analysis and process control design. Of particular note were the developments of computer techniques for the simulation of complex boiler dynamics and for the synthesis of multivariable boiler-turbine controls. In recognition of these contributions, he was the recipient of G.E.'s Managerial Award and G.E.'s Ralph Cordiner Award. He also made significant contributions in the study of electrical machine dynamics, their voltage and governing controls and to the analysis and implementation of system load-frequency controls. From 1963 to 1969, he held the position of Senior Application Engineer heading a group of systems engineers specializing in electric utility control and dynamics problems.

Mr. de Mello joined Power Technologies, Inc. at the time of its formation in August of 1969 as a Principal Engineer, Dynamics and Control and Secretary Treasurer. He was appointed Vice President-Secretary in 1973. He also serves as a Director of PTEL, PTI's affiliate in Brazil. From 1974 to 1976, he was project manager for PTI and PTEL in system and design studies for transmission from Itaipu, the world's largest 800 kV system. He also served on the Advisory Board of the Study Group for Itaipu transmission.

He has authored over 40 technical papers in IEEE, ISA, American Power Conference, World Power Conference, and other utility industry publications, and has participated in many lectures to professional society groups. He has served on the IEEE System Controls Subcommittee (Chairman of Technical Sessions Task Force), and the joint IEEE Working Group on System Dynamic Performance, and has also served as an Instructor of General Electric's Power Systems Engineering Course and currently teaches dynamic and operational subjects in PTI's Power Technologies Course.

Mr. de Mello is a Fellow of IEEE, a Senior Member of ISA, a registered Professional Engineer in New York State and a member of CIGRE.

TECHNICAL PAPERS AND ARTICLES

AUTHORED AND CO-AUTHORED BY F.P. DE MELLO

1. "Technical and Economic Aspects of Power Transmission in Brazil," World Power Conference, Sectional Meeting, Rio de Janeiro, 1954.

2. "Evaluation of Transient Systems Response," Transactions of the AIEE, Part II, Applications and Industry, No. 44, Sept. 1959, pp. 177-186.

3. "Random Paralleling of Aircraft Alternators," Transactions of the AIEE, Part II, Applications and Industry, No. 39, Nov. 1958, pp. 322-330, (co-author H.M. Rustebakke).

4. "Z Transform Techniques for the Analysis of Systems," AIEE Conference Paper CP-60-1291, 1960, Fall General Meeting, Chicago, Ill.

5. "Reclosing Transients on Induction Motors with Terminal Capacitors," Transactions of the AIEE, Part III, Power Apparatus and Systems, Vol. 79, Feb. 1961, pp. 1206-13, (co-author G.W. Walsh).

6. "Analog Computer Studies of System Overvoltages Following Load Rejections," IEEE Transactions on Power Apparatus and Systems, Vol. 82, No. 65, April 1963, pp. 42-49, (co-authors, A.C. Dolbec, D.A. Swann, and M. Temoshok).

7. "Plant Dynamics and Control Analysis," IEEE Transactions on Power Apparatus and Systems, Paper 63-1401, 1963, Vol. S82, pp. 664-678.

8. "Simulation as a Design Tool for Plant Jack McDonough Boiler Controls," ISA 7th National Power Instrumentation Symposium Proceedings, 1964, pp. 35-46, (co-authors, W.M. Stephens and D.N. Ewart).

9. "Stability of Synchronous Machines as Affected by Excitation Systems, Machine and System Parameters," Proceedings of the American Power Conference, 1965, Vol. 27, pp. 1150-1159, (co-authors, D.N. Ewart and M. Temoshok).

10. "Power Plant Response," Report by IEEE Working Group, IEEE Transactions on Power Apparatus and Systems, March 1967, p. 384, (co-authors, J. Baker, W.D. Marsh, P.H. Light, and J. Donelson).

11. "Effect of Prime-Mover Response and Governing Characteristics on System Dynamic Performance," Proceedings of the American Power Conference, 1966, Vol. 28, pp. 1074-85, and Spectrum, October 1966, pp. 106-111, (co-authors, C. Concordia, L.K. Kirchmayer, and R.P. Schulz).

12. "Digital Computer Simulation of Generation Systems," Third Congress of IFAC, London, June 20-25, 1966, (co-author, L.K. Kirchmayer).

13. "Turbine Energy Controls Aid in Power System Performance," Proceedings of the American Power Conference, 1966, Vol. 28, pp. 438-445 (co-authors, D.N. Ewart, M. Temoshok and M.A. Eggenberger).

14. "Analysis and Design of Controls for a Once-Through Digital Simulation," ISA 9th National Power Instrumentation Symposium Proceedings, 1966, pp. 11-30, (co-authors, D.J. Ahner, C.E. Dyer, and V.C. Summer).

15. "Simulation of Plant Dynamics and Design of Plant Control Systems," Southeastern Electric Exchange Meeting, New Orleans, April 1966, (co-author, R.E. Paulson).

16. "A Digital Computer Program for the Automatic Determination of Dynamic Stability Limits," IEEE Transactions on Power Apparatus and Systems, July 1967, (co-author D.N. Ewart).

17. "Boiler Pressure Control Configurations," Conference Paper 31-CP-67-12, IEEE Winter Power Meeting, January 1967, (co-author F.P. Imad).

18. "FACE - A Digital Dynamic Analysis Program," 1967 PICA Conference Record, Power Industry Computer Applications Conference, pp. 83-94, (co-author D.N. Ewart).

19. "BWR Capabilities for Utility Load Following and Regulation Requirements," (co-author J.J. Hogle).

20. "Nuclear Power Plant Training Simulator," Capital Cities Control Conference (ISA and AIChE), May 13-14, 1969, (co-author R.J. Mills).

21. "Concepts of Synchronous Machine Stability as Affected by Excitation Control," IEEE Transactions on Power Apparatus and Systems, Vol. 88, April 1969, (co-author, C. Concordia).

22. "Effects of Excitation, Turbine Energy Control, and Transmission on Transient Stability," IEEE Transactions on Power Apparatus and Systems, 70-TP-203-PWR, IEEE Winter Power Meeting, 1970, (co-authors, P.G. Brown, E.H. Lenfast, and R.J. Mills).

23. "Modern Concepts of Power System Dynamics - The Effects of Control," IEEE Summer Power Meeting, 1970 Tutorial Paper.

24. "Process Dynamics in Electric Utility Systems," ISA Paper 505-70, International Conference and Exhibit of ISA, October 26-29, 1970, Philadelphia, PA.

25. U.S. Patent No. 3601 617 - Turbine Control System with Early Valve Actuation Under Balanced Conditions, (co-inventors - M.A. Eggenberger and R.J. Mills, August 24, 1971.

26. "Specifying Training Simulators for Power Plant Operators," ISA 15th National Power Instrumentation Symposium, May 22-24, 1972, (co-author R.J. Mills).

27. "MW Response of Fossil-Fueled Steam Units," IEEE Working Group on Power Plant Response to Load Changes, Joint Power Generation Conference, IEEE Transactions on Power Apparatus and Systems, Vol. PAS-92, No. 2, March/April 1973, pp. 455-463, (co-author D.N. Ewart).

28. "Automatic Generation Control: Part I - Process Modeling," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-92, No. 2, March/April 1973, pp. 710-715, (co-authors, R.J. Mills and W.F. B'Rells).

29. "Automatic Generation Control: Part II - Digital Control Techniques," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-92, No. 2, March/April 1973, pp. 716-724, (co-authors, R.J. Mills and W.F. B'Rells).

30. "Planning Design and Operation of Complex Utility Systems," State of the Art Paper presented at "Power Tech 80," U.S. Dept. of Commerce Technical Sales Seminar in Brazil, Argentina, and Paraguay, July-August 1973.

31. "Interactive Computation in Power System Analysis," IEEE Proceedings, (special issue on Computers in the Power Industry), 1974, (co-authors, J.M. Undrill, R.J. Mills, and T.E. Kostyniak).

32. "Load Rejection Overvoltages as Affected by Excitation System Control," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-94, No. 2, March/April 1975, pp. 280-287, (co-authors, L.M. Leuzinger and R.J. Mills).

33. "Concepts of Power System Dynamic Stability," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-94, No. 3, May/June 1975, pp. 827-833, (co-author T.F. Laskowski).

34. "Power System Dynamics - Overview," Symposium on Adequacy and Philosophy of Modeling: Dynamic System Performance, IEEE paper #75 CHO 970-4 PWR.

35. "Subsynchronous Oscillations - Shaft System Interactions," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-95, No. 4, July/August 1976, pp. 1456-1464, (co-author J.M. Undrill).

36. "Some Aspects of Transmission System Planning and Design in Large Developing Countries," presented at the Henniker Conference, August 22-27, 1976.

37. "Derivation of Synchronous Machine Parameters from Tests," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-96, No. 4, July/August 1977, pp. 1211-1218, (co-author J.R. Ribeiro).

38. "Practical Approaches to Supplementary Stabilizing from Accelerating Power," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-97, No. 5, September/October 1978, pp. 1515-1522, (co-authors, L.N. Hannett and J.M. Undrill).

39. "Automatic Generation Control," presented at the 1977 IEEE Summer Power Meeting, (co-author J.M. Undrill).

40. "Estudos para a Selecao final do Sistema de Transmissao de Itaipu," (co-authors, C. Peixoto, A. Vian, J.P. Mello, and M. Baker), IV Seminario Nacional de producao e transmissao, Rio, 1977.

41. "Estabilidade Dinamica de Sistemas com carga remota," (co-authors, E. Figueiredo, J. Mountford, A. Pedroso, and J. Ribeiro), idem, 1977.

42. "Estudos de Fluxo de Potencia e Estabilidade para comparacao das alternativas do sistema de transmissao de Itaipu, compensacao serie versus suporte de tensao," (co-authors, A. Fadini, J.D. Mountford, and S.T. Ferreira), idem, 1977.

43. "Thyristor-Controlled Reactors Analysis of Fundamental Frequency and Harmonic Effects," 1978 Power Engineering Society Winter Meeting Text of "A" Papers, IEEE Product No. 78 CH 1295-5-PWR, (co-authors, B.K. Johnson, L.N. Hannett, D. Birfet, and J. Toulemonde).

44. "Automatic Generation Control," presented at 1978 IEEE Winter Power Meeting, New York, NY, Jan. 29-Feb. 3, 1978, New York, NY, (co-author, J.M. Undrill).

45. Studies of Subsynchronous Oscillations in Itaipu Series Compensated Transmission Alternatives," English version of paper prepared for presentation at the 4th National Conference on Production and Transmission of Electric Energy, Rio de Janeiro, Brazil, Sept. 18-24, 1977, (co-authors, J.M. Undrill, L.N. Hannett, B.K. Johnson, L.M. Leuzinger, and M. Pereira).

46. "Coordinated Application of Stabilizers in Multimachine Power Systems," presented at the IEEE PES Winter Meeting, New York, NY, Feb. 4-9, 1979, (co-authors, P.J. Nolan and T.F. Laskowski).

POWER TECHNOLOGIES, INC.
Biographical Summary

DALE E. HEDMAN
Principal Engineer
Transmission System Engineering

Mr. Hedman holds a B.S. and M.S. in Electrical Engineering from the University of Nebraska (1959) where he was also elected a member of Sigma Tau (Engineering), Pi Mu Epsilon (Mathematics) and Eta Kappa Nu (Electrical Engineering) honorary fraternities. His early experience included assignments with Omaha Power District and Westinghouse Corporation. He joined the General Electric Company and completed the three-year advanced engineering course while participating in several assignments throughout the company. In 1962, he joined General Electric's Electric Utility Engineering Operation and has since specialized in transient analysis of power systems. Mr. Hedman joined PTI at its formation in 1969 and was assigned as Principal Engineer in charge of transmission system engineering.

Mr. Hedman's experience in transient analysis has included extensive use of both analog and digital methods. He has participated in many Transient Network Analyzer (TNA) studies resulting in insulation coordination recommendations on high-voltage and extra-high-voltage systems throughout the World. His early experience in insulation coordination systems led to assignments as project engineer on system design studies for several utilities including systems in Brazil, Mexico, and Australia. These project studies included insulation coordination and equipment specifications of terminal equipment as well as machine and system response following load rejection. As project engineer, he coordinated these studies with stability and load flow work. He has also been project engineer on a high-voltage laboratory study of contaminated insulators; the technical results of this study were presented in an IEEE paper which won the 1969 National Paper Award.

Mr. Hedman has been involved in the system evaluation of the performance of transmission products. He was instrumental in the transient network analyzer studies developing the electrical design of the surge suppressing resistor preinsertion scheme used in both the 500-kV and 345-kV circuit breakers. Numerous studies involving power circuit breaker recovery voltage rate of rise and line dropping or capacitor switching system requirements have been performed. He has also had extensive experience in the application of lightning arresters on high-voltage and extra-high-voltage systems. This experience has related both to the electrical design features of the lightning arrester and to the interpretation of system results as they relate to terminal equipment. The work in application of lightning arresters and insulation coordination has also been carried out in the design of the Pacific Northwest Intertie ± 400-kV DC System.

He has developed a number of digital three-phase traveling wave programs which were subsequently used for the design of many EHV systems. The most recent work in this area has been reported in the technical literature. The PTI digital switching surge program has been used both by PTI and major utilities in the analysis of switching overvotlages on EHV and UHV systems. Other work has included analysis of ferroresonant conditions as well as telephone interference (TIF) from harmonics on d-c transmission lines. Particularly significant work has been done by Mr. Hedman on the propagation of carrier current signals on multi-phase overhead transmission lines. This work has been of substantial importance in the interpretation of unusual phenomena resulting during field tests of carrier currents on long EHV transmission lines.

Mr. Hedman was project engineer on the design and construction of a modern transient network analyzer purchased by McGraw Edison of Canonsburg, Pa. This TNA incorporates many advanced features and utilizes electronic power supplies along with special model components to accurately model power system lines, switches, transformers, and lightning arresters.

He developed the PTI Power Technology Course on Transmission Line Theory and Insulation Coordination and has served as an instructor on these courses. He is a Fellow of IEEE and is a member of CIGRE Working Group 13.5 - Design Evaluation of Transient Network Analyzers. He is a member of the IEEE Power Systems Communication Committee, a member of the IEEE Surge Protective Devices Committee, the IEEE representative to C62 (Lightning Arresters), and Secretary of IEC-TC37 (Lightning Arresters.)

Mr. Hedman joined Power Technologies, Inc. at the time of its formation in August of 1969 as a Principal Engineer, Transmission System Engineering. He was appointed Treasurer in 1976.

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TECHNICAL PAPERS AND ARTICLES

AUTHORED AND CO-AUTHORED BY D.E. HEDMAN

1. "EHV Predict and Control Switching Surge Levels," Electrical World, 1963, (co-author, D.D. Wilson).

2. "Overvoltage Transients Follow Load Rejection," Electrical World, October 1963, (co-author R.P. Schulz).

3. "Switching of Extra-High-Voltage Circuits - II: Surge Reduction with Circuit Breaker Resistors," IEEE Transactions on Power Apparatus and Systems, December 1964, pp. 1196-1205, (co-authors, I.B. Johnson, C.H. Titus, and D.D. Wilson).

4. "Switching Surge Field Tests on The Arizona Public Service Field Tests," IEEE Transactions on Power Apparatus and Systems, July 1968, pp. 1635-1648, by Joint Arizona Public Service and General Electric Task Force.

5. "Trade-offs Developed for Arrester Selection," Electrical World, November 6, 1967, (co-author, E.C. Sakshaug).

6. "Propagation on Overhead Transmission Lines - I: Theory of Modal Analysis," IEEE Transactions on Power Apparatus and Systems, March 1965, pp. 200-205.

7. "Propagation on Overhead Transmission Lines - II: Earth Conduction Effects and Practical Results," IEEE Transactions on Power Apparatus and Systems, March 1965, pp. 205-211.

8. "Carrier Current on Transmission Lines - I: Modal Analysis Interpretation of Carrier," IEEE Conference Paper, Summer Meeting, 1967.

9. "345 kV Line, Sixty-Cycle Ground Wire Losses," IEEE Transactions on Power Apparatus and Systems, February 1968, pp. 420-427, (co-author, H.C. Sampers).

10. "Testing of Contaminated Insulation," presented at the Insulation Coordination Forum, Little Rock, AR, May 3, 1967, (co-author, K.P. Tongen).

11. "Field and Laboratory Tests of Contaminated Insulators for the Design of the State Electricity Commission of Victoria's 500-kV Lines," IEEE Transactions on Power Apparatus and Systems, May 1968, pp. 1216-1239, (co-authors, J.Johnson, R.T. Henderson, W.S. Price, and F.J. Turner). Prize Paper Award, Summer IEEE Meeting, 1969.

12. "Carrier Attenuation on Long Transmission Lines," 70CP 133-PWR presented at the IEEE Winter Power Meeting, New York City, 1970.

13. "Attenuation of Traveling Waves on Three-Phase Lines," IEEE paper no. 70 TP-544-PWR, Summer Power Meeting, 1970.

14. "Traveling Wave Terminal Simulation by Equivalent Circuit," IEEE Paper No. 71 TP 148-PWR, presented at the IEEE Winter Power Meeting, New York, NY, Jan. 31-Feb. 5, 1971, (co-author, J.D. Mountford).

15. "Theoretical Evaluation of Multiphase Propagation," IEEE paper no. 71 TP 149-PWR, presented at the IEEE Winter Power Meeting, New York, NY, Jan. 31-Feb. 5, 1971.

16. "New Method Speeds Analysis of System Transients," Electrical World, April 1971.

17. "The Calculation of Switching Surges: Part I - A Comparison of Transient Network Analyzer Results," ELECTRA, No. 19, November 1971, pp. 67-68, (co-authors, CIGRE Working Group 13.05).

18. "The Calculation of Switching Surges," ELECTRA, (co-authors, CIGRE Working Group 13.05).

19. "Simplified Approach to EHV System Insulation," Electrical World, January 1972, (co-author, J.D. Mountford).

20. "Digital Calculation of Switching Surge Overvoltages," 1972 IEEE Canadian Communication and EHV Conference, Nov. 9-10, 1972.

21. "Distortion of Traveling Waves on Three Phase Transmission Lines," 1972 IEEE Canadian Communications and EHV Conference, Nov. 9-10, 1972. Also conference paper presented at IEEE Summer Power Meeting, Vancouver, BC, 1972.

22. "Circuit Breaker Requirements for the Furnas Centrais Eletricas, S.A. 500 kV System," Conference paper presented at IEEE Summer Power Meeting, Vancouver, BC, 1972, (co-authors, C.A. Peixoto and J.D. Mountford).

23. "A New TNA - Part I - Design Features Provide Versatile Capabilities," Conference paper presented at IEEE Summer Power Meeting, Vancouver, BC, 1973, (co-authors, J.K. Dickson, W.A. Lewis, and R.M. Webler).

24. "A New TNA - Part II, Capabilities Extend Performance and System Application," Conference Paper presented at IEEE Summer Power Meeting, Vancouver, BC, 1973, (co-authors, J.K. Dickson, W.A. Lewis, S.N. Talukdar, and R.M. Webler).

25. "Power Circuit Breaker Transient Recovery Voltages," F75-550-4, IEEE Summer Power Meeting, 1975, (co-author, S.R. Lambert).

26. "Economic and Environmental Sensitivity Analysis for 765 kV Line Design," IEEE Conference paper C75-172-2, (co-authors, S. Cluts, R.E. Clayton, and H.W. Zaininger).

27. "Digital Modeling of AC/DC Systems," to be presented at IEEE International Conference, Winnipeg, Canada, July 1980, (co-authors, R.E. Clayton, F.P. de Mello, and B.K. Johnson).

28. "800 kV Itaipu Transmission System - Surge Arrester and Circuit Breaker Special Duties," CIGRE-1980, (co-authors, J.A. Jardini, A. Vian, C.A. Peixoto, and S.O. Frontin).

POWER TECHNOLOGIES, INC.
Biographical Summary

ROBERT J. RINGLEE
Principal Engineer
System Research Studies
and Reliability Analysis

R.J. Ringlee holds B.S. (1946) and M.S. (1948) degrees in Electrical Engineering from the University of Washington and a Ph.D in Mechanics (1964) from Rensselaer Polytechnic Institute. As an undergraduate at the University of Washington, he was elected to Phi Beta Kappa (Scholastic), Tau Beta Pi (Engineering), Sigma Xi (Science), and Zeta Mu Tau (Mathematics) honorary fraternities and was awarded the B.S. degree Magna Cum Laude.

His early experience included a position as Associate Instructor for the University of Washington. In 1948, he joined the General Electric Company Advanced Engineering Program. Upon completion of this three-year study program, he was appointed Advanced Development Engineer with the Power Transformer Department in Pittsfield, Mass. He specialized in magnetic core development including vibration and noise instrumentation and control, structural design, and core iron processing.

In 1955, he was appointed a design subunit supervisor in the Power Transformer Engineering Section with responsibility for special power transformer design and in 1957, he was assigned subunit responsibility for power transformer design characteristics. In 1960, he transferred to the Electric Utility Engineering Operation in Schenectady as a Senior Application Engineer to undertake a doctoral program at RPI. In 1967, he was appointed to the position of Manager of System Reliability for the Electric Utility Engineering Operation. From 1965 to 1969, he served as leader for a project on system and equipment reliability for the GE departments serving the electric utility industry.

Dr. Ringlee joined Power Technologies, Inc. as a Principal Engineer at the time of its founding in August of 1969.

He has directed projects in reliability assessment for bulk power supply systems, transmission systems, substations and power plants. Among these projects are review and recommendation for improvement of large distribution network performance for a public service commission, review of planning and operating policies for bulk transmission systems in Brazil and in the U.S., review of transmission performance assessment methods for a large U.S. transmission system, review of generation assessment methods for a large power pool, and preparation of several programs for reliability assessments for system operations. He has also directed the preparation of application programs for energy management systems. These have included generation control, dispatch, and commitment scheduling, generation and transmission contingency assessment, and maintenance assessment.

Dr. Ringlee is a registered Professional Engineer in New York State and is also licensed to practice electrical and mechanical engineering in Massachusetts. He is a Fellow of IEEE, a Fellow of the American Association for the Advancement of Science, and a member of CIGRE. He is Chairman of the IEEE Power System Engineering Committee, past Chairman of the Application of Probability Methods Subcommittee and of two working groups related to Transmission System Reliability Evaluation, PROSD and APMTP, a member of working groups on performance indices and definitions for generating station equipment, a former member of IEEE Working Group 71-4, Load Forecasting, is an expert advisor to CIGRE Study Committee 32, and is a past chairman of the Task Force on Load-Weather Correlation.

For the past thirty years, he has taught over 25 engineering courses on electrical and mechanical engineering topics and on elementary probability, statistics, and calculus on variations. He has held adjunct positions with the University of Massachusetts Extension Service and with the Polytechnic Institute of Brooklyn.

He has authored and co-authored over sixty technical articles in IEEE, CIGRE, and in other engineering journals and is co-author of the monograph, Power System Reliability Calculations. Three of his IEEE papers have been awarded IEEE prizes. He has been awarded two patents and a managerial citation for his work in vibration and noise suppression.

Power
Technologies,
Inc.

TECHNICAL PAPERS

AUTHORED AND CO-AUTHORED BY R. J. RINGLEE

NOISE CONTROL

1. "Recent Contributions to Transformer Audible Noise Control," (co-author, W.B. Conover), Power Apparatus and Systems, April, 1955, p. 77.

2. "Etudes Acoustiques des Transformateurs sur Modelles Reduits," CIGRE Paper No. 128, 1956.

3. "Use of Scale Models for Studying Power Transformer Audible Noise," (co-authors, K.A. Johnson and M.W. Schulz, Jr.), Noise Control Vol. 2, No. 2, March, 1956, pp. 54-60.

4. "A New Load-Tap Changing Switch - LRT-68 Reduces Maintenance 50% and Noise by 20 db," (co-author O.P. McCarty), Distribution, July, 1956, p. 3.

5. "Some Characteristics of Audible Noise of Power Transformers and Their Relationship to Audibility Criteria and Noise Ordinances," (co-author M.W. Schulz, Jr.), Power Apparatus and Systems, June, 1960, pp. 316-323.

OIL PRESERVATION SYSTEMS

6. "An Improved Method of Oil Preservation and its Effect on Gas Evolution," (co-authors, W.J. Degnan and G.G. Doucette), Power Apparatus and Systems, 1958, pp. 657-663.

7. "Tank Pressures Resulting from Internal Explosions," (co-author, N.W. Roberts), Power Apparatus and Systems (III), 1959, pp. 1705-10.

8. "Features of the Atmoseal Oil Preservation System," (co-authors, D.R. Baldwin and E.J. Sherman), Power Apparatus and Systems (III), 1958, pp. 969-972.

HYDROTHERMAL COORDINATION AND POWER SYSTEM CONTROL

9. "Susquehanna River Short-Range Hydro-Thermal Coordination," (co-author, L.T. Anstine), Power Apparatus and Systems, April 1963, pp. 185-191.

10. "Optimal Control of Thermal-Hydro System Operation," (co-author, L.K. Kirchmayer), IFAC Proceedings, 1963.

11. "An Investigation of Pumped-Storage Scheduling," (co-author, C.D. Galloway), Power Apparatus and Systems, Vol. 85, May, 1966, pp. 459-465.

12. "Bounds for Convex Variational Programming Problems Arising in Power System Scheduling and Control," JACC Proceedings, Stanford, pp.429-435.

13. "Bounds for Convex Variational Programming Problems Arising in Power System Scheduling and Control," IEEE Transactions, Vol. AC-10, January, 1965, pp. 28-35.

14. "Economic Scheduling and Automatic Dispatching of a Hydro-Thermal Power System," American Power Conference Proceedings, 1964, pp. 1116-1122.

15. "On Variational Programming Problems Arising in Control Synthesis," Ph.D Thesis, Rensselaer Polytechnic Institute, 1964.

16. "Sensitivity Methods for Economic Dispatch of Hydroelectric Plants," JACC Proceedings, RPI, 1965.

17. "Sensitivity Methods for Economic Dispatch of Hydroelectric Plants," IEEE Transactions, Vol. AC-10, July, 1965, pp. 315-322.

SYSTEMS RELIABILITY

18. "Frequency and Duration Methods for Power System Reliability Calculations, Part I - Generation System Model," (co-authors, J.D. Hall and A.J. Wood), Power Apparatus and Systems, Vol. 87, pp. 1787-96.

19. "Frequency and Duration Methods, Part II - Demand Model and Capacity Reserve Model," (co-author, A.J. Wood), Power Apparatus and Systems, Vol. PAS-88, 1969, pp. 375-388.

20. "Frequency and Duration Methods, Part III - Generation System Planning," (co-authors, C.D. Galloway, L.L. Garver and A.J. Wood), 69TP126 published in Power Apparatus and Systems, March, 1969, Canadian Electrical Association, Montreal.

21. "Frequency and Duration Methods, Part IV - Models for Multiple Boiler-Turbines and for Partial Outage States," (co-authors, V.M. Cook and A.J. Wood) 69TP127 published in Power Apparatus and Systems.

22. "Implications of Reliability Models Used in Power Generation System Planning," (co-authors, C.D. Galloway, L.L. Garver and A.J. Wood), Annals of Assurance Sciences, Vol. 1, 1968, pp. 112-118.

23. "Distribution System Reliability Performance," (co-author, M.W. Gangel), IEE Conference Publication No. 34, Part 1, Contributions, pp. 288-294.

24. "Distribution System Reliability Performance," (co-author, M.W. Gangel), Power Apparatus and Systems, Vol. 87, pp. 1657-1664.

25. "Distribution System Reliability Estimates," Distribution, December, 1966.

26. "A Look at Substation Reliability," (co-authors, C.R. Heising and H.O. Simmons), (A) - 1968 Proceedings, American Power Conference, pp. 1252-61 - (B) - 1968 Minnesota Power Systems Conference, October, 1968.

27. "On Procedures for Reliability Evaluations of Transmission Systems," (co-author, S. D. Goode), 69TP654 published in Power Apparatus and Systems.

28. "Steps in Measuring Service Continuity, Techniques for Comparing Feeder Outage Rates," (co-author, E. S. Gardner), EEI Transmission and Distribution Committee 105th Meeting, January 25, 1968, Los Angeles.

29. "Steps in Measuring Service Continuity," (co-author. E. S. Gardner), Transmission and Distribution, June, 1968.

30. "Relationship Between Annual Failure Rate, Average Life, and Economic Life of Distribution Equipment," (co-authors, H.E. Campbell, A.J. Wood, and J.A. Smith), published in the Proceedings of the 1969 American Power Conference.

31. "Reliability Models and Measures for Power System Operation," (co-author, A.J. Wood), American Power Conference, Chicago, Illinois, April 22, 1970.

32. "Comments on Collection and Utilization of Outage Data," presented at a meeting of the Canadian Electrical Association, March 10, 1970, Toronto.

33. "Frequency and Duration Methods, Part V - Models for Delays in Unit Installations and Two Interconnected Systems," (co-author, A. J. Wood), presented at the 1970 Winter Power Meeting, New York, Paper No. 70TP158-PWR.

34. "Reliability Procedures for Substations," IEEE Tutorial Course, Text 71M30-PWR, Sept., 1970, pp. 51-57.

35. "A Survey of Experience with Equipment Availability," AECL Symposium on Reliability, presented at Chalk River Nuclear Laboratories, Oct. 1970, (AECL-3670).

36. "A New Generation Production Cost Program to Recognize Forced Outages," PICA Proceedings, May, 1971, (co-authors, M.A. Sager and A.J. Wood).

37. "Suggested Definitions Associated with The Status of Generating Station Equipment and Useful in the Application of Probability Methods for System Planning and Operation," IEEE Application of Probability Methods Subcommittee, Ad Hoc Working Group on Definitions, (co-authors, V. M. Cook and J. P. Whooley).

38. "Generation System Planning Models for Hydro-Thermal Systems," American Power Conference, Chicago, Illinois, April 22, 1971 and IEEE Paper 71CP706-PWR, (co-authors, N.D. Reppen, A.J. Wood, E.G. Graham, G.E. Gunter, and D.C. Muttart).

39. "Use of Outage Statistics for Operating and Spinning Reserve Assessments," 1971 Power Generation Conference, St. Louis, IEEE Paper 71CP701-PWR, (co-authors, L.T. Anstine, A. Street and S.D. Goode).

40. "Models and Techniques for Evaluating Power Plant Auxiliary Equipment Reliability," 1971 Power Generation Conference, St. Louis, IEEE Paper 71CP702-PWR.

41. "Improving Power System Reliability Through Standardization with Specific Reference to Nuclear Power Reactors," (co-author, W.L. Fleischman), First International Conference on Structured Mechanics in Reactor Technology, Berlin, September, 1971.

42. "The Influence of the Environment on System Growth Patterns," Public Utilities Fortnightly, November, 1971, (co-authors, L.O. Barthold and A.J. Wood).

43. "A Multi-Area Approach to State Estimation in Power System Networks," presented at the 1972 IEEE Summer Power Meeting.

44. "Experience with Weather Sensitive Load Models for Short and Long Term Forecasting," (co-authors, S.L. Corpening and N.D. Reppen), IEEE Power Engineering Society Winter Power Meeting, New York, Jan.28-Feb. 2, 1973.

45. "Direct Economic Dispatch," (co-authors, O.J. Denison and N.D. Reppen), IEEE Power Engineering Society Winter Power Meeting, New York, Jan. 28-Feb. 2, 1973.

46. "An Automated Method for Long-Range Planning of Transmission Networks," (co-authors, W.R. Puntel, N.D. Reppen, J.E. Platts, W.A. Ryan and P.J. Sullivan), PICA Proceedings 73 CHO 740-1, presented at 1973 PICA Conference.

47. "The Effects of Measurement Non-Simultaneity, Bias, and Parameter Uncertainty on Power System State Estimation," (co-authors, K.A. Clements and O.J. Denison), PICA Proceedings 73 CHO 740-1, presented at 1973 PICA Conference

48. "Power System Reliability Calculations," Published by the MIT Press, Copywright 1973, (co-authors, Roy Billinton and A.J. Wood).

49. "A Study Mode Multi-Area Economic Dispatch Program," (co-authors, D.E. Cameron II and J.E. Kohler), IEEE Conference Paper C74-157-4, presented at the IEEE Winter Power Meeting, 1974.

50. "Treatment of Parameter Uncertainty in Power System State Estimation," IEEE Conference Paper C74 311-7, IEEE 1974 Summer Power Meeting, (co-author, K.A. Clements).

51. "Operating Reserve and Generation Risk Analysis for The PJM Interconnection," (co-authors, L.G. Leffler, R.J. Chambliss, G.A. Cucchi, and N.D. Reppen), IEEE Trans. T74-350-5, Presented at 1974 Winter Power Meeting, Prize Paper Award.

52. "Economic System Operation Considering Valve Throttling Losses - Part II," IEEE Transactions No. 64, February, 1963, pp. 615-622.

53. "Maintenance Reserve Evaluation for Large Systems," Proceedings 1975 Annual Reliability and Maintainability Conference, Jan. 28-30, 1975, Washington, D.C., Paper #75RM080, (co-authors, L.G. Leffler, R.J. Chambliss, G.A. Cucchi, K.A. Clements, and G.W. Woodzell).

54. "Prediction of Reliability and Availability of HVDC Valve and HVDC Terminal," IEEE PA&S, Vol. PAS-89, No. 4, (co-author, C.F. Heising).

55. "Probabilistic Methodologies - A Critical Review," Presented at ERDA sponsored Engineering Foundation Conference at Henniker, N.H., Aug. 17-22, 1975, (co-authors, N.D. Reppen, K.A. Clements, A.J. Wood, and B.F. Wollenberg).

56. "Overview of Optimization Methods," presented at 1976 Winter PES Meeting, Tutorial Course on Application of Optimization Methods to Power System Engineering, (co-author, B.F. Wollenberg).

57. "Environmental Factors in Siting of Transmission Facilities," (co-authors, L.O. Barthold and W.R. Puntel), Presented at the American Power Conference in Chicago, Ill. April 19, 1972.

58. "Impact of Advanced Fuel Fusion on Electric Power Transmission," (co-authors, R. W. de Mello, N. D. Reppen and D. D. Wilson), presented at the First Symposium of Clean Fusion, Washington, April 30, 1976.

59. "Impact of Transmission System Design Criteria on System Reliability," (co-author, N. D. Reppen), presented at the Canadian Electric Association Meeting, Toronto, Ontario, March 24, 1976.

60. "Suggested Definitions Associated with The Status of Generating Station Equipment," - Rev. 7, (co-authors, V.M. Cook and R.C. Chan), Ad Hoc Working Group on Definitions, presented at the Summer Power Meeting, Portland, Oregon, July, 1976.

61. "A Program for Composite Bulk Power Electric System Adequacy Assessment," to be presented at the IEE International Conference on Reliability of Power Supply Systems, London, February, 1977, (co-authors, G. Jorgensen, P. Dandeno, and W. Puntel).

62. "Common Mode Forced Outages of Overhead Transmission Lines," by Task Force on Common Mode Outages of Bulk Power Supply Facilities of the APM Subcommittee of the PES Committee, IEEE Transactions on Power Apparatus and Systems, Vol. PAS-95, No. 3, May/June 1976.

63. "Reliability Criteria and Predictions for the Transmission System of Itaipu," presented at the 4th National Conference on Production and Transmission of Electric Energy, Rio de Janeiro, Brazil, Sept. 18-24, 1977.

64. "Exploiting Diversity and Dispatch for Improved Operating Efficiency," for presentation at the Energy Conservation Technology Conference, Aug. 22-23, 1977, Washington, D.C.

65. "Reliability Criteria and Predictions for Transmission Stations on an 800 kV System," (co-authors C.A. MacArthur and G.E. Scott), presented at the 1978 Engineering Foundation Conference on Power System Reliability - Research Needs and Priorities, Asilomar Conference Grounds, Pacific Grove, CA, March 5-9, 1978.

66. "Current Research in Adequacy Assessment of Bulk Power Supply Systems," (co-author K.A. Clements), presented at the 1978 Engineering Foundation Conference on Power System Reliability - Research Needs and Priorities, Asilomar Conference Grounds, Pacific Grove, CA, March 5-9, 1978.

67. "Integration of Interactive Network Analysis Techniques into Real Time Energy Control Systems," (co-authors, O.J. Denison and B.F. Wollenberg), to be presented at the IFAC Conference in Tokyo.

POWER TECHNOLOGIES, INC.
Biographical Summary

JOHN M. UNDRILL
Principal Engineer

John Undrill received a Bachelor of Engineering degree with first class honors, from the University of Canterbury, Christchurch, New Zealand, in 1963, and a Ph.D. from the same University in 1965. Following a Post Doctoral Fellowship at the University of Toronto, he joined the General Electric Company's Electric Utility Engineering Operation in 1966. He joined PTI in 1971 and was appointed a Principal Engineer in 1978.

Dr. Undrill is responsible for the development of computing systems used in PTI's analytical work, and for computer systems and program products that are used by electric utilities worldwide. Programs and equipment developed under his guidance are applied in system engineering studies, in dispatch offices, and in studies of specific plant behavior problems.

Dr. Undrill has played a leading role in the development of digital computer modeling of the electrical, thermal, mechanical, and hydraulic sections of power systems. This has involved both analytical and testing work. Much of his testing work has been done as consultation to major utilities where his hydro plant testing has investigated dynamic performance of turbines, governors, and complex hydraulic conduits configurations. His testing work on large boilers has led to improved understanding of the interactions between the fuel and airflow control systems. Dynamic models developed by Dr. Undrill are adapted both to large scale power system simulators and to specific trouble-shooting needs in areas as diverse as hydro-governing and the starting of large industrial drives. Dr. Undrill developed methods for the analysis of subsynchronous oscillations and interactions between electric systems and shaft torsional motions in turbine generators and industrial drives. These methods have been widely applied to systems in the U.S., South America, and Africa.

He serves on the IEEE subcommittees on Computer and Analytical Methods and on System Dynamic Performance. He also serves on IEEE Task Forces on Subsynchronous Oscillations and on Common Stability Data Exchange Format. He is a Fellow of the IEEE and a registered engineer in New York, New Zealand, and Ontario.

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TECHNICAL PAPERS AND ARTICLES

AUTHORED AND CO-AUTHORED BY JOHN UNDRILL

1. "Simulation Studies of Hydro Governing with AC and HVDC Interconnections," New Zealand Engineering, December 1965, pp. 512-520, (co-author, J.L. Woodward).

2. "Simulation Studies of Hydro Governing with AC and HVDC Interconnections," IEE (London) Conference on HVDC Transmission, Pub. No. 22, September 1966, pp. 146-150, (co-author, J.L. Woodward).

3. "Nonlinear Hydro Governing Model and Improved Calculation for Determining Temporary Droop," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-86, April 1967, pp. 443-453, (co-author, J.L. Woodward).

4. "On the Construction of MacFarlane's Generalized Functional Matrix," Proceedings of the IEE, (London), Vol. 114, Jan. 1967, pp. 166-167.

5. "Power System Stability Studies by the Method of Liapounov - Pt. I, State Space Approach to Synchronous Machine Modeling, and Pt. II, The Interconnection of Hydro Generating Sets," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-86, July 1967, pp. 791-801 and pp. 802-811.

6. "Dynamic Stability Calculations for an Arbitrary Number of Interconnected Synchronous Machines," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-87, 1968, pp. 835-844.

7. "Structure in the Computation of Power System Nonlinear Dynamical Response," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-88, 1969, pp. 1-6.

8. "Multi-Computer Configurations and Diakoptics: Linear Power Flow in Power Pools," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-88, 1969, pp. 789-796, (co-author, H.H. Happ).

9. "Dispatcher's Load Flow for the REMVEC Dispatch Center," IEEE Summer Power Meeting, Dallas, Texas, June 1969, Paper No. 69 CP-660-PWR, (co-authors, O.J. Denison and D. Hayward).

10. "Automatic Sectionalization of Power System Networks for Network Solutions," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-90, pp. 46-53, 1971 (co-author, H.H. Happ).

11. "Computational Aspects of Power System Dynamic Simulation," IEEE International Convention, New York, March 1970.

12. "Construction of Power System Electro-Mechanical Equivalents by Modal Analysis," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-90, No. 5, pp. 2049-2059, 1972, (co-author, A.E. Turner).

13. "Electromechanical Equivalents for Use in Power System Stability Studies," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-90, No. 5, pp. 2060-2071, 1972, (co-authors, E.M. Gulachenski, J.A. Casazza, and L.K. Kirchmayer).

14. "Power System Dispatch Office Automation Functions," New Zealand Engineering, Vol. 27, pp. 167-170, 1972.

15. "Computing in Engineering Dynamics," New Zealand Engineering, Vol. Vol. 27, pp. 291-295, 1972.

16. "Modified Nodal Iterative Load Flow Algorithm to Handle Series Capacitors," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-92, pp. 1379-1387, 1973, (co-author, R. Podmore).

17. "Take the Blinders off Your Computer Studies," Electric Light and Power, Vol. 51, pp. 66-69, October 1973.

18. "Influence of Hydro Plant Design on Regulating and Reserve Response Capacity," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-93, pp. 1192-1200, 1974, (co-author, W. Strauss).

19. "Interactive Computation in Power System Analysis," IEEE Proceedings on Power Apparatus and Systems, Vol. 62, pp. 1009-1018, 1974, (co-authors, F.P. de Mello, R.J. Mills, and T.E. Kostyniak).

20. "Interactive Dynamic Simulation by Digital Computer," ISA Transactions, Vol. 14, pp. 33-40, 1975, (co-author, T.F. Laskowski).

21. "Advanced Power System Fault Analysis Method," IEEE Transactions on Power Apparatus apaau a aua Vol. PAS-94, pp. 2141-2150, 1975, (co-author, T.E. Kostyniak).

22. "Furnace Implosions - An Analysis and Proposed Protective Systems," Proceedings of the American Power Conference, pp. 421-435, Chicago, 1975, (co-author, P.C. Euchner).

23. "Main Fuel Trip and Furnace Draft," ASME Annual Meeting, Houston, Texas, Nov. 1975, (co-authors, W.I. Hodsden and H.D. Vollmer).

24. "Equipment and Load Modeling in Power System Dynamic Simulation," U.S. Energy Research and Development Administration, Conference Record CONF-750867, 1975.

25. "Subsynchronous Oscillations: Part I, Comprehensive Stability Analysis," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-95, pp. 1446-1455, 1976, (co-author, T.E. Kostyniak).

26. "Subsynchronous Oscillations: Part II, Shaft System Dynamic Interactions," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-95, pp. 1456-1464, 1976, (co-author, F.P. de Mello).

27. "Automatic Generation Control, IEEE Tutorial Course Publication No. 77TU010-9-PWR, pp. 17-26, 1977, (co-author, F.P. de Mello).

28. "Draft Control System Design, Simulation and Test for a High Implosion Potential Boiler," American Power Conference, Chicago, Illinois, April 1977.

29. "Practical Approach to Supplementary Stabilizing from Accelerating Power," IEEE Summer Power Meeting, Paper No. F77-524-2, 1977, (co-authors, F.P. deMello and L.N. Hannett).

30. "Turbine-Generator Impact Torques in Routine and Fault Operations," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-98, pp. 618-628, 1979, (co-author, L.N. Hannett).

31. "Coordinated Application of Stabilizers in Multimachine Power Systems," IEEE Winter Power Meeting, Paper No. F79-175-1, 1979.

POWER TECHNOLOGIES, INC.
Biographical Summary

J.C. WESTCOTT
Principal Engineer
Power Plant Performance
and Automation

Mr. Westcott graduated with a B.Sc degree in Mechanical Engineering from Rensselaer Polytechnic Institute in 1946.

After various test program assignments with General Electric, he was assigned to the Steam Research Section of Steam Turbine Engineering in 1948. His first assignment, in the Aerodynamic Development Laboratory, was the basic development of turbine steam path components. After six months, he was assigned responsibility for the operation of the laboratory, and remained in that post until mid-1950. His next assignment involved research on thermal transients during the starting and loading of the first tandem-opposed flow, reheat turbine built by G.E.

From 1951 through 1960, he was responsible for conducting turbine design information tests during actual power plant operation. During this time, he organized and conducted over twenty test programs, including Dresden 1, General Electric's first large nuclear unit. He was also responsible for the design and implementation of new instrumentation and measurement techniques for such variables as flow, electric energy, pressure and temperature.

In December of 1960, Mr. Westcott joined the Electric Utility Engineering Operation of General Electric's Electric Utility Sales Division. In his initial assignment, he developed methods for dynamic modeling of power plants with particular emphasis on the advanced design problem of steam generator control. This involved conducting response tests on both super-critical and sub-critical steam generators.

In 1964, he joined the newly formed Power Plant Automation Operation which was responsible for application engineering and marketing support for automation and monitoring systems used in nuclear and fossil-fueled power plants. He was appointed manager of this operation in 1970. During this assignment, he was responsible for the design and implementation of several permanently installed instrumentation systems which provide measurement accuracies sufficient for the requirements of the ASME Performance Test Code for steam turbine acceptance tests. He has also conducted numerous seminars for electric utilities and architect/engineering companies on power plant performance monitoring, instrumentation and cooling water optimization techniques.

Mr. Westcott joined Power Technologies, Inc. in July 1973 as a Principal Engineer responsible for the company's activities in power generation.

Mr. Westcott is a member of ASME and ISA. He is Chairman of the Special Flow Measurements Committee for the ASME Performance Test Codes and is a member of the Performance Test Codes Supervisory Committee.

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TECHNICAL PAPERS AND ARTICLES

AUTHORED AND CO-AUTHORED BY J.C. WESTCOTT

1. "Procedures for Testing Large Steam Turbine-Generators in Central Stations," presented at ASME Annual Fall Meeting, 1955, (co-author E.M. Kratz).

2. "Throat Tap Nozzles Used for Accurate Flow Measurements," presented at Annual Fall Meeting, ASME, 1959, (co-author K.C. Cotton).

3. "Methods for Measuring Steam Turbine-Generator Performance," presented at Annual Fall Meeting ASME, 1960, (co-author, K.C. Cotton).

4. "Digital Computer Application for Accurate Steam Turbine Performance Testing," presented at the National Power Conference, San Francisco, September 26-27, 1961, AIEE Conference Paper #61-985, (co-authors, K.C. Cotton and T.J. Glass).

5. "Temperature Measurement for Power Plant Performance," presented at an EEI Task Force on Power Plant Performance, October 24, 1961, (co-author I.C.H. Campbell).

6. "Monitoring and Evaluation of Steam Plant Performance," presented at the 1962 Conference for Electric Utility Application Engineers, General Electric Company.

7. "The Application of a Combined Sensor and Computer System for Accurate Performance Monitoring of Plant Jack McDonough," American Power Conference Proceedings, Chicago, March 26-28, 1963.

8. "Flow and Energy, the Most Critical Measurements for Power Plant Evaluation," presented at the National Power Conference, September 27-October 1, 1964, IEEE Conference paper #64-365, (co-author, I.C.H. Campbell).

9. "Assurance of Integrity of Measurement Systems," presented at EEI 5th Annual Meeting, Task Force on Computer Applications for Utility Engineering, October 28-29, 1964, St. Louis, Missouri.

10. "The Application of a Combined Sensor and Computer System for Accurate Performance Monitoring," presented at the 11th Annual Southeastern Instrument Society of America Conference and Exhibit, April 27-29, 1965, Chattanooga, Tenn.

11. "Instrumentation System for On-Line Turbine Performance Monitoring," presented at the ISA 10th National Power Instrumentation Symposium, May 9, 1967, Dallas, Texas, (co-author R.L. Harper).

12. "Turbine Acceptance Testing Using a Power Plant Information System," ASME Paper No. 69-WA/PTC-2, presented at the Winter Annual Meeting, Nov. 16-20, 1969, Los Angeles, California, (co-author K.C. Cotton).

13. "Calibration of Instrument Systems," presented at 15th National Power Instrumentation Symposium, May 22-24, 1972, Dallas, Texas.

14. "Interface Between the Computer and Power Plant - Transducing the Process Variable," presented at the Edison Electric Institute, Computer Task Force Forum, Sept. 25, 1972, Detroit, Michigan.

15. "Power Demand - Its Effect on Control of Generation," keynote address, Applications Symposium on Power Plant Dynamics, Control and Testing, University of Tennessee, Knoxville, Oct. 8-10, 1973.

16. "Condenser Cooling Water Management for Performance Optimization," ISA Power Instrumentation Symposium, May 20-22, 1974, Boston, Mass.

17. "Moving Toward the Next Generation of Training Simulators," presented to the EEI Engineering and Technical Computer Committee, June 10, 1975, (co-author, R.J. Mills).

18. "Turbine Cycle Test System at Potomac Electric Power Company," presented at ASME Winter Meeting, December 1980, (co-author, H.G. Crim, Jr.).

POWER TECHNOLOGIES, INC.
Biographical Summary

DEL D. WILSON
Principal Engineer
Experimental Programs and Distribution Systems
Underground Cable Systems

Mr. Wilson graduated with a B.S. in Electrical Engineering from Montana State College in 1959. He joined the General Electric Company in that year and completed assignments in the Industry Control Department, Instrument Department, and the Lightning Arrester and Cutout Operation. In 1960, Mr. Wilson joined the Electric Utility Engineering Operation and, from 1961 to 1964, was Engineer-in-Charge of the Transient Network Analyzer. He directed and participated in numerous EHV switching surge and insulation coordination studies which defined precedents in system insulation coordination.

Mr. Wilson contributed to the specification of system requirements for two generations of surge arresters and participated in transient studies and analyses which defined presently applied techniques of EHV circuit breaker surge suppression. He was responsible for the forecasting of future system requirements for medium and large power transformers and for performing systems analysis for transformer applications and field problems.

Mr. Wilson was responsible for the design and construction of the General Electric HVDC simulator, the first large-scale functional HVDC simulator in the United States. Following the completion of the simulator, he was assigned the task of redesigning and construction of the General Electric Transient Network Analyzers.

In 1969, Mr. Wilson was appointed Manager, AC Transmission Studies, responsible for the areas of surge analysis, statistical line design, product application, insulation coordination, general system protective relaying studies, and special system design studies. In the same year, he was named initial editor of Transmission Magazine, a new publication directed toward the transmission segment of the industry. He served as editor until 1972, when he was appointed Manager of Engineering Studies and Projects for the Group Technical Resources Operation of the Power Delivery Group in Philadelphia. During this period, he was also project manager for a large-scale UHV transmission system feasibility study.

Mr. Wilson was author and instructor of a course in surge phenomena and insulation coordination and has participated as lecturer in several industry and university seminars. He has authored or co-authored over 50 published technical articles and contributed to two books.

In 1974, Mr. Wilson joined Power Technologies, Inc. as a Principal Engineer responsible for experimental programs in overhead transmission and distribution and the company's Saratoga Research and Development Center facility. In this capacity, he has directed and participated in several projects oriented toward reduction of conductor clearances for 69-230 kV transmission involving construction and testing of experimental lines. Results of this work are published in the Transmission Line Reference Book, 115-238 kV Compact Line Design, (EPRI, 1978). Continuing efforts in this area include experimental and analytical work on high phase order transmission - the use of more than the conventional three phases.

He is also responsible for PTI's Distribution Systems and Underground Cable Systems activities. Distribution projects include a large-scale project to measure and analyze fault currents on U.S. distribution systems, including development of instrumentation; field testing and analysis directed toward a method of detecting high impedance faults; and analysis of higher voltage distribution systems. Underground cable projects include methods of locating leaks in oil-filled cables and defining failure modes due to thermo-mechanical motion of cables and resultant design modifications.

Mr. Wilson is a Fellow of IEEE, a member of the IEEE Transmission and Distribution Committee, the Administrative Subcommittee, and a former chairman of the General Systems Subcommittee. He is a member of CIGRE, an expert advisor to CIGRE SC 33, a United States technical advisor to Technical Committees No. 8 and 28 of the International Electrotechnical Commission, represents the U.S. on TC28 Working Group No. 3 (Phase-to-Phase Insulation Coordination), and is Recording Secretary of ANSI Committee C92 (Insulation Coordination).

Power
Technologies,
Inc.

TECHNICAL PAPERS AND ARTICLES

AUTHORED AND CO-AUTHORED BY D. D. WILSON

1. "Switching Surges Due to Energization or Reclosing," Proceedings of the American Power Conference, Vol. XXIII, pp. 729-736, 1961, (co-authors, I.B. Johnson and R.F Silva).

2. "Phase-to-Phase Switching Surges on Line Energization," AIEE Transactions, Vol. II, pp. 298-302, 1962, (co-authors, I.B. Johnson and R.F. Silva).

3. "Switching Surge and Dynamic Voltage Study of Arizona Public Service Company's Proposed 345 kV Transmission System Utilizing Miniature Analyzer Techniques," AIEE Transactions, Vol. II, pp. 302-312, 1962, (co-authors, W.H. Croft, R.H. Hartley, and R.L. Linden).

4. "Switching Surges and Arrester and Gap Performance During 220 kV Line Dropping Tests," AIEE Transactions, Vol. II, pp. 312-320, 1962, (co-author, W.N. Rothenbuhler).

5. "500 kV Line Design - Model Studies," IEEE Transactions on Power Apparatus and Systems, Vol. II, pp. 572-581, 1963, (co-authors, W.R. Johnson and J.G. Anderson).

6. "Predict and Control Switching Surge Levels in EHV Systems," Electrical World, December 30, 1963, (co-author, D.E. Hedman).

7. "Switching of EHV Circuits, Part II, Surge Reduction with Circuit Breaker Resistors," IEEE Transactions on Power Apparatus and Systems, Paper No. 64-113, Vol. 83, No. 12, pp. 1196-1205, presented at IEEE Winter Power Meeting, February, 1964, (co-authors, D.E. Hedman, I.B. Johnson, and C.H. Titus).

8. "Switching Surge Field Tests at 345 kV - Arizona Public Service Company," Conference Paper presented at WESCON (IEEE) Meeting in Los Angeles, August, 1964, (member of GE-APS Task Force).

9. "Switching Surges and the Guri Project," presented at the I Asamblea de Ingenieria Electrica in Caracas, Venezuela, May 13-17, 1965.

10. "Simulator Developed for Studies on Northwest-Southwest HVDC Intertie," Electrical World, September 13, 1965.

11. "General Electric High Voltage DC Simulator," IEEE News Bulletin, Vol. 5, No. 2, February, 1966, (co-author, J.E. Hudson).

12. "EHV Insulation Coordination Balances Protection with Economics," Electrical World, March 21, 1966.

13. "EHV-DC Simulator," IEEE Transactions on Power Apparatus and Systems, Pt. III, Vol. PAS-85, No. 11, pp. 1101-1107, Nov. 1966, (co-authors, E.M. Hunter and J.E. Hudson).

14. "Transmission: Today's Threshold, Tomorrow's Challenge," Central Illinois Public Service Company Engineering Seminar, June 8-9, 1967.

15. "Application and Protection of Autotransformers," presented at Southeastern Electric Exchange, April, 1967, (co-author, E.J. Sheely).

16. "Effect of Frequency and Voltage Variations on Power System Equipment," presented at Southeastern Electric Exchange, October 1967, (co-author, M. Temóshok).

17. "Near Resonant Coupling on EHV Circuits: II - Methods of Analysis," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-87, No. 2, pp.326-334, February 1968, (co-author, M.H. Hesse).

18. "Switching Surge Field Tests on the Arizona Public Service 345 kV System," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-87, No.7, pp. 1635-1648, July 1968, (APS-GE Task Force).

19. "Future Transmission Voltage Levels," presented at IEEE Region Six Meeting, Phoenix, Arizona, April 16-18, 1969, (co-author, L.O. Barthold).

20. "Shunt Reactor Compensation on Present and Future Transmission Systems," presented at American Power Conference, Chicago, Ill., April 22-24, 1969, (co-author, J.M. Feldman).

21. "Economic Determination of Transformer Size -- Reliability Aspects," presented at the 46th NELPA Spring Conference, Great Falls, Montana, April 24, 1969, (co-author, R.J. Ringlee).

22. "Phase-Phase and Phase Neutral Switching Surges on 500 kV Open-Ended Lines," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-88, No. 5, pp.660-665, May 1969.

23. "Phase-Phase Switching Surges on 500 kV Transformer Terminated Lines, Part I: 500 kV Circuit Breaker Operation," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-89, No. 5/6, pp. 685-690, May/June 1970.

24. "Phase-Phase Switching Surges on 500 kV Transformer Terminated Lines, Part II: Switching from Low Voltage Terminals," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-89, No. 5/6, pp. 691-697, May/June, 1970

25. "Accuracy Emphasized in Use of Analyzer," Electrical World, October 1, 1971, (co-author H.O. Simmons).

26. "Switching Surges and Insulation Protection," Transmission Magazine, Vol. 3, No. 2, October 1971.

27. "Series Compensated Lines - Voltage Across Circuit Breakers and Terminals Caused by Switching," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-92, No. 3, pp. 1050-1056, May/June 1972.

28. "Correlation of Power Transformer Short Circuit Standards with Service Requirements," Proceedings of the American Power Conference, Vol. 34, pp. 1060-1069, 1972, (co-authors, E.T. Jauch and W.J. McNutt).

29. "The Role of Manufacturers in Electric Power Systems Analysis," NSF RANN Workshop on Systems Analysis Needs in Electric Power Systems, University of Missouri - Columbia, Sept. 11-13, 1973, (co-author, T.H. Lee).

30. "Substations - Evolving Concepts and Equipment," presented at the Pennsylvania Electric Association, Lancaster, Pa., October 16-17, 1973.

31. "Economic Feasibility of UHV," presented at UHV Transmission Seminar sponsored by the Electric Power Research Institute, Pittsfield, Mass., April 23-25, 1974.

32. "Current Limiting Devices for Transmission and Distribution Applications," Proceedings of the American Power Conference, Vol. 36, pp. 1105-1113, 1974, (co-author, P. Barkan).

33. "Economic and Technical Progress in HVDC," presented at the IEEE Power Engineering Summer Meeting and Energy Resources Conference, Anaheim, California, July 24-29, 1974, paper no. C74 460-2, (co-author, J.L. Fink).

34. Transmission Line Reference Book - 345 kV and Above, published by Electric Power Research Institute, 3412 Hillview Ave., Palo Alto, CA 94304, Copyright 1975, (co-author).

35. "Trends in Overhead Transmission," Conference Record of the 1976 IEEE Region 6, Pub. No. 76CH1062 REG 6, April 1976, pp. 71-78.

36. "Impact of Advanced Fuel Fusion on Electric Power Transmission," Proceedings of the First Symposium on Advanced Fuel-Clean Fusion, Nuclear Instruments and Methods (Issue 144), 1977, (co-authors, R.W. de Mello, N.D. Reppen, and R.J. Ringlee).

37. Transmission Line Reference Book/ 115-138 kV Compact Design, published by Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, CA 94304, Copyright 1977, (co-author).

38. "Compaction--A New Frontier in Transmission Research," paper no. A77 648-9, presented at 1977 IEEE PES Summer General Meeting, July 17-22, Mexico City, (co-authors, L.O. Barthold and I.S. Grant).

39. "Electrical Design of 115-138 kV Compact Transmission Lines," paper no. A77 506-9, presented at 1977 IEEE PES Summer General Meeting, July 17-22, Mexico City, (co-authors, R.E. Clayton, I.S. Grant, and J.R. Stewart).

40. "Electromagnetic Environmental Aspects of New High Voltage Electric Power Transmission Technologies," Proceedings of the 1977 IEEE International Symposium on EMC, Seattle, WA, August 2-4, 1977, (co-author J.R. Stewart).

41. "Compact HV Transmission Now Feasible," Electrical World, September 15, 1977, (co-authors, L.O. Barthold and I.S. Grant).

42. "Maintenance of Compact High Voltage Transmission Lines," Conference Record, First International Conference on Live Line Maintenance - IEEE/PES ESMO-77, Montreal, Canada, October 5-7, 1977.

43. "High Phase Order Transmission—A Feasibility Analysis, Part I - Steady State Consideration," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-97, No. 6, pp. 2300-2307, Nov./Dec. 1978, (co-author, J.R. Stewart).

44. "High Phase Order Transmission—A Feasibility Analysis, Part II - Overvoltages and Insulation Requirements," ibid. pp. 2308-2317, (co-author, J.R. Stewart).

45. "Increased Right-of-Way Efficiency at HV Transmission Levels," Transmission and Distribution Magazine Engineering/Operating Conference, Chicago, Ill., May 3-4, 1978.

46. "High Phase Order Transmission--Can It Save R-O-W's, Replace UHV?" Electric Light and Power, pp. 41-42, May 1978.

47. "Compact Transmission Lines Increase ROW Efficiency," Transmission and Distribution, pp. 44-51, September 1978.

48. Phase-Phase Switching Surge Performance for HV Lines," Proceedings of the 7th IEEE/PES Conference and Exposition on Overhead and Underground Transmission and Distribution, April 1-6, 1979, (co-authors, I.S. Grant and A.S. Paulson).

49. High Phase Order Transmission Switching Surge Analysis," presented at the 7th IEEE/PES Conference and Exposition on Overhead and Underground Transmission and Distribution, April 1-6, 1979, (co-author, J.R. Stewart).

50. "115-138 kV Compact Line Design," presented at the Annual Joint Spring Conference, NELPA, Spokane, WA, April 22-24, 1979.

51. "Phase-to-Phase Switching Surge Testing for Compact HV Line Design," Third International Symposium on High Voltage Engineering (IEEE), Milan, Italy, Aug. 28-31, 1979, (co-authors, I.S. Grant, R.E. Kennon, and A.S. Paulson).

POWER TECHNOLOGIES, INC.
Biographical Summary

ALLEN J. WOOD
Principal Engineer
System & Corporate Planning

A.J. Wood earned degrees in Electrical Engineering from Marquette (B.E.E., 1949), Illinois Institute of Technology (M.S.E.E., 1951), and Rensselaer Polytechnic Institute (Ph.D, 1959) and was elected to membership in Tau Beta Pi (Eng.), Eta Kappa Nu (Electrical Eng.), Pi Mu Epsilon (Math.), and Sigma Xi (Science). In 1949, he joined Allis-Chalmers Mfg. Co. in West Allis, Wisconsin where he held engineering and sales assignments. He was a graduate student and teaching assistant at I.I.T. in Chicago during the 1950-51 academic year.

In 1951, he joined the General Electric Co. in Lynn, Mass. to work on electrical design, noise and vibration, and the analysis of heat transfer in turbine generators. In 1952, Dr. Wood moved to the Analytical Engineering Section in Schenectady, N.Y. where he participated in the analysis and development of 400-cycle aircraft electric power systems. For two years, Dr. Wood supervised the Power Systems Engineering Course offered by G.E. and taught portions of the program. He assisted in the teaching of a new aircraft electrical systems course and developed and taught the first year's course in Utility Planning Systems Economics when it was made a part of the PSEC curriculum. The varied analytical projects carried on during this period include the development of analog and digital models of step-voltage regulator controls and an investigation of the effects of turbine generator rotor iron eddy currents on reactances. He participated in numerous studies of power system behavior and the analysis of electromechanical systems.

Dr. Wood was a member of the team led by the late S.B. Crary which conducted extensive economic studies relating to the use of EHV transmission voltages, the economic benefits of twin conductors, and the potential economic advantages of dc power transmission as compared to ac. He became a member of the Electric Utility Engineering Operation in 1960 where his area of interest was in utility planning, both for power systems and utility corporate planning. In the system planning field, Dr. Wood has participated in the development of new probabilistic techniques for generation planning, new economic evaluation methods, and has directed joint research projects on new system planning methods. For several years, he was G.E.'s project leader for the pool planning study being carried out by the utilities of New York State.

In 1966, he became the project leader for G.E. in a joint project to create a digital computer corporate model of the Boston Edison Company. This set of integrated computer programs, announced in mid-1968, simulates the energy production process and the corporate business processes. Besides the conventional areas of revenue and expense forecasting, the model includes consideration of the economic effects of nuclear fuel management procedures and permits the study of their consequences on the utility's financial position.

Dr. Wood is a registered Professional Engineer in New York State, a member of the American Nuclear Society and is a Fellow of the IEEE, where he is a member of the Education Committee of the Power Group and the Computer and Analytical Methods Subcommittee. He has authored over 50 technical articles for various journals, magazines and symposia. For several years, he has served RPI as an adjunct professor in their Electric Power Engineering graduate program. He has participated in numerous courses and programs in sales, engineering analysis, numerical methods, business management, econometrics, reliability methods, and nuclear fuel management.

Dr. Wood joined Power Technologies, Inc. as a Principal Engineer at the time of its formation in August 1969. He has been project engineer for a power pool consulting effort and several system and corporate planning efforts for utilities in the U.S., Canada, and Australia. He has directed efforts to develop corroate financial models for both large and medium sized utilities. New generation production cost programs which recognize the important effects of unit forced outages have also been developed and supplied to a number of U.S. utility companies. He has participated in corporate model seminars in the U.S., Europe, and Australia. He is the co-author of the book, Power System Reliability Calculations, M.I.T. Press, 1973. He has served as project engineer for several bulk power system planning projects for utilities in the U.S. and abroad and for the U.S. Atomic Energy Commission. Most recently, he has been involved in projects involving the study of energy storage systems, the study of energy storage systems, the study of peak load pricing and in consulting assignments involving the potential interconnection of large regions of the power systems in the U.S.

Power
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TECHNICAL PAPERS

AUTHORED AND CO-AUTHORED BY A. J. WOOD

1. "Reduction of Noise Produced by Small and Medium Two-Pole Turbine Generators," AIEE Transactions, Vol. 72, Part III, 1953, pp. 36-40, (co-author, L.P. Shildneck).

2. "Effects of Abnormal Conditions on Aircraft Parallel AC Power Systems", AIEE Transactions, Vol. 72, Part II, 1953, pp. 379-385 (co-author, S.C. Caldwell).

3. "An Economic Study of High Voltage Transmission," AIEE Transactions Vol. 75, Part III, 1956, pp. 695-705, (co-author, J.M. Henderson).

4. "Synchronizing Out-of-Phase," AIEE Transactions, Vol. 76, Part III, 1957, pp. 1-8.

5. "Conductor Economics on High-Voltage Transmission Systems," AIEE Transactions, Vol. 76, Part III, 1957, pp. 502-511 (co-author J.M. Henderson).

6. "An Economic Study of AC Versus DC Overhead Transmission," AIEE Transactions, Vol. 78, Part III, 1959, pp. 338-348 (co-authors, S.B. Crary and C. Concordia).

7. "An Analysis of Solid Rotor Machines, I - Operational Impedances and Equivalent Circuits," AIEE Transactions, Vol. 78, Part III, 1959, pp. 1657-65.

8. "Ibid, II - The Effects of Curvature" - Loc. Cit., pp. 1666-1672, (co-author, C. Concordia).

9. "Ibid., III - Finite Length Effects" - AIEE Transactions, Vol. 79, Part III, 1960, pp. 21-26, (co-author, C. Concordia).

10. "Ibid., IV - An Approximate Nonlinear Analysis" - Loc. Cit., pp. 26-31, (co-author C. Concordia).

11. "Determination of Reserve Requirements of Two Interconnected Systems," IEEE Transactions, Power Apparatus and Systems, April 1963, pp. 18-33, (co-authors, V.M. Cook, C.D. Galloway and M.J. Steinberg).

12. "Generation Planning Programs for Interconnected Systems, I - Expansion Programs," IEEE Transactions, Power Apparatus and Systems, Supplement, 1963, pp. 761-774 (co-authors, E.S. Bailey, C.D. Galloway and E.S. Hawkins).

13. "Ibid., II - Production Costing Program," Loc. Cit., pp. 775-788 (co-authors, E.S. Bailey, C.D. Galloway and E.S. Hawkins).

14. "Protection of Parallel, AC Aircraft Systems Against Excitation Failures," AIEE Conference Paper, 1955 (co-authors, H.H. Britten and S.C. Caldwell).

15. "Power System Planning Economics," AIEE Conference Paper, 1958.

16. "Digital Complex Arithmetic Analysis of Power System Problems," AIEE Conference Paper, 1959.

17. "Computer Analysis of 32-Step Voltage Regulator Performance," AIEE, 1960 (co-authors, A.C. Dolbec, M.W. Gangel and W.W. Green).

18. "Computers Applied to the Design of Generation and Transmission Systems," IEEE Conference Paper 60-5073, 1960 PICA Meeting, (co-author, C.D. Galloway).

19. "Generation-Transmission Expansion Planning", presented at Power Systems Computation Conference, Stockholm, Sweden, June 1966. Published in Conference Proceedings, Part V, Report 76 (co-authors, C.D. Galloway, L.L. Garver and L.K. Kirchmayer).

20. "Education for Engineering Economics," IEEE Transactions, Power Apparatus and Systems, Vol. PAS-86, No. 12, December 1967, pp. 1493-97, (co-author H.M. Rustebakke).

21. "Financial Simulation - A Tool for Evaluation of Generation Additions", presented to Committee on Power Generation, AEIC, Schenectady, N.Y., Feb. 27, 1967, (co-authors, W.D. Marsh and R.L. Thompson).

22. "Digital Computer Applications in Planning of Large Systems," presented to local IEEE Section, Schenectady, N.Y., April 4, 1967.

23. "Linear Programming as an Aid in Planning Kilovar Requirements," IEEE Transactions, Power Apparatus and Systems, Vol. PAS-87, No. 12, December, 1968 (co-authors L.L. Garver, and R.M. Maliszewski).

24. "Forecasting with an Input-Output Model", IEEE Transactions, Power Apparatus and Systems, Vol. PAS-87, No. 6, June 1968, pp. 1401-1411.

25. "Frequency and Duration Methods for Power System Reliability Calculations: I - Generation System Model," IEEE Transactions, Power Apparatus and Systems, Vol. PAS-87, No. 9, pp. 1787-96, (co-authors, J.D. Hall and R.J. Ringlee).

26. "Ibid., - Part II, Demand Model and Generation Capacity Reserve Model," presented at 1968 IEEE Summer Power Meeting, June 1960, Chicago, Ill., IEEE Transactions, Power Apparatus and Systems, Vol. PAS-88, No. 4, pp. 375-388, (co-author, R.J. Ringlee).

27. "Ibid., Part III - Generation System Planning", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-88, No. 8, Aug. 1969, pp. 1216-1223, (Co-authors, C.D. Galloway, L.L. Garver and R.J. Ringlee).

28. "Ibid., Part IV - Models for Multiple Boiler Turbines and Partial Outage States," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-88, No. 8, Aug. 1969, pp. 1224-1232 (co-authors, V.M. Cook and R.J. Ringlee).

29. "Planning of Large Systems," Public Utilities Fortnightly, Vol. 81, No. 1, Jan. 4, 1968, pp. 16-25. Also published in the Proceedings of the IFAC Second Optimal Systems Planning Symposium, Case Institute of Technology, Cleveland, Ohio, June, 1968, pp. 154-164.

30. "Implications of Reliability Models and Indices Used in Utility Power Generation System Planning", Proceedings of the 7th Reliability and Maintainability Conference, sponsored by S.A.E., AIAA, and ASME, San Francisco, Calif., July 1968, pp. 112-118, (co-authors, C.D. Galloway, L.L. Garver, and R.J. Ringlee).

31. "Boston Edison's Corporate Model," presented at EEI System Planning Committee Meeting, Milwaukee, Wisconsin, October, 1968 (co-author, J.R. Mitiguy).

32. "An Electric Utility Corporate Model," IEEE Paper 69CP110-PWR. Presented at 1969 IEEE Winter Power Meeting, New York City, January, 1969, (co-authors, J.F. Carlin, C.D. Galloway, R.H. Lyons, J.R. Mitiguy, E.F. Murphy and M.A. Sager).

33. "The Corporate Model Program," Proceedings of Sixth Power Industry Computer Application (PICA) Meeting, IEEE Publication 69-C1-PWR, 1969, pp. 557-564 (co-author, M.A. Sager).

34. "Relationship Between Failure Rate, Average Life, and Economic Life for Distribution Equipment," Proceedings of the American Power Conference, Vol. 31, 1969, pp. 928-937 (co-authors, H.E. Campbell, R.J. Ringlee and J.A. Smith.

35. "An Application of Corporate Models in Generation Planning," Proceedings of the American Power Conference, Vol. 31, 1969, pp. 458-467 (co-authors, M.L. McNelly, and R.L. Thompson).

36. "Generation-Transmission System Planning and Economic Evaluation," Proceedings of 1969 Power Systems Computation Conference, Rome, Italy, Vol. 2, paper P. 3 (co-authors, C.D. Galloway, L.L. Garver, L.K. Kirchmayer).

37. "Corporate Model of an Electric Utility," IEEE Spectrum, June, 1969, Vol. 6, No. 6, pp. 75-84 (co-authors, J.F. Carlin, C.D. Galloway, R.H. Lyons, J.R. Mitiguy, E.F. Murphy and M.A. Sager).

38. "Frequency and Duration Methods, Part V: Models for Delays in Unit Installations and Two Interconnected Systems," presented at the IEEE Winter Power Meeting, New York, 1970. IEEE Transactions on Power Apparatus and Systems, Vol. PAS-90, 1971, pp. 79-88 (co-author R.J. Ringlee).

39. "Reliability Models and Measures for Power System Operation," Proceedings of the American Power Conference, Vol. 32, 1970, pp. 931-939.

40. "Corporate Models - A New Tool for Planning," presented at the 1970 Summer Power Meeting, Los Angeles, Calif., 70 TP 794-PWR.

41. "Corporate Models - A Tool for Planning," - Proceedings of Symposium on Power Systems for the 1970's, Purdue University, Lafayette, Ind., May 13, 1970.

42. "A New Generation Production Cost Program to Recognize Forced Outages," 1971 PICA Proceedings, (co-authors, M.A. Sager and R.J. Ringlee) Also Trans. of IEEE, Paper T 72 159-7.

43. "Generation System Planning Models for Hydro-Thermal Systems," Proceedings of the 1971 American Power Conference, (co-authors, E.G. Graham, G.E. Gunter, C.D. Muttart, N.D. Reppen and R.J. Ringlee.)

44. "Generation and Financial Planning in the State Electricity Commission of Victoria," Proceedings of the 8th World Energy Conference, (co-authors, A.A. Cope, I.W. Meldrum, P.F. Moir.)

45. "Corporate Models for Electricity Supply Utility Planning," Electrical Review, July 2, 1971, Vol. 189, pp. 11-14.

46. "Power System Production Cost Calculations - Sample Studies Recognizing Forced Outages" (co-author, M.A. Sager) - IEEE Transactions Paper T72 158-9.

47. "Influence of Environment on System Growth Patterns" (co-authors, L.O. Barthold and R.J. Ringlee) Public Utilities Fortnightly, Vol. 88 no. 11, November 25, 1971.

48. "Probability Analysis of Power System Reliability" (A.J. Wood - Editor), IEEE Publication 71M30-PWR.

49. "Corporate Models in the Electric Utility Industry" - B.I.F.O.A. Symposium on Model Based Corporate Planning, University of Cologne, Cologne, W. Germany, March, 1972. Published in the Symposium Proceedings.

50. "Energy Production Cost Models" - Symposium on Modeling and Simulation, University of Pittsburgh, April 1972. Published in the Conference Proceedings

51. "Electric Utility Corporate Models," (co-author M.A. Sager). Fourth Power Systems Computation Conference, Grenoble, France, September, 1972. Published in the Conference Proceedings.

52. "Electric Utility Corporate Models" (co-author, M.A. Sager). Public Utilities Fortnightly Vol. 90, No. 3, August 3, 1972, pp. 30-35.

53. "Northern States Power Company's Corporate Model" Paper I-D, Proceedings of 1973 IEEE PICA Meeting, June 1973, (co-authors M.A. Sager, G.N. Sherburne, and D.R. Throndson).

54. "Power System Reliability Calculations," (book) Fall 1973, M.I.T. Press, Cambridge, Mass. (co-authors R. Billinton and R.J. Ringlee)

55. "Multi-Area Generation System Reliability Calculations," IEEE Trans., Vol. PAS-94, No. 2, March-April 1975, pp. 508-517, (co-author, C.K. Pang).

56. "Power System Network Expansion," presented at Nuclear Utilities Planning Methods Symposium, Chattanooga, Tenn., Jan. 1974, published in ORNL-TM-4443, Oak Ridge National Laboratory, Oak Ridge, Tenn. (co-author, W.R. Puntel).

57. "Multi-Area Power System Reliability Calculations: Extensions and Examples," IEEE paper No. A 75 535-5, presented at Summer Power Meeting, July 1975, (co-author C.K. Pang).

58. "Probabilistic Methodologies - A Critical Review," Proceedings of ERDA Symposium on System Engineering for Power: Status and Prospects, US ERDA publication CONF-750867, pp. 290-308, Jan. 1976, (co-authors, K.A. Clements, N.D. Reppen, R.J.Ringlee and B.F. Wollenberg).

59. "Application of Optimization Methods in Power Systems Engineering," (A.J. Wood - Organizer and Editor), IEEE Publication 76 CH 1107-2-PWR, 1976.

60. "Multi-Area Generation Reliability Studies," presented at 1978 IEEE PES Summer Power Meeting, Los Angeles, CA, (co-authors, C.K. Pang, R.L. Watt, and J.A. Bruggeman).

61. "Error Analysis of Econometric Load Forecasting Models," presented at 1978 IEEE PES Summer Power Meeting, Los Angeles, CA, (co-author, K.A. Clements).

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POWER TECHNOLOGIES INC

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