PTI'S MERGER WITH STONE & WEBSTER MANAGEMENT CONSULTANTS, INC.

As many of you have heard, PTI has been acquired by Stone & Webster Management Consultants, Inc. (MCI) effective August 14, 1998. PTI's association with MCI represents an historic move to add commercial and regulatory capabilities to our technical competencies, a combination critical to balance the needs of an increasingly competitive global energy industry.

MCI has approximately 120 professionals who offer a broad range of management consulting skills in electricity, gas, industrial process, telecommunications, and water. Their key practice areas include:

• Core utility concerns
• General management consulting
• Y2K embedded systems
• Project financing review services
• Electric wholesale and government regulation issues
• Energy resource management services
• Retail pricing for unbundled utilities services

To augment the combined skills of PTI and MCI, we are also able to draw on S&W Engineering to provide EPC contracting and associated disciplines.

The relationship with Stone & Webster will provide a stronger base to broaden PTI's consulting services businesses and accelerate our development of innovative software and hardware solutions. PTI will remain in Schenectady, New York, and will continue to operate as an independent company.

We are confident that the complementary skills and geographical reach of a combined PTI and Stone & Webster will increase our responsiveness to your needs and provide you with an important expansion of services and products to address the issues of the future.

FIRST PEDS OPERATIONAL AT NIAGARA MOHAWK PHOTOVOLTAIC SITE

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INTRODUCTION

PTI recently completed the development of the first Power Enhancement and Delivery System (PEDS) for Niagara Mohawk Power Corporation. As its name implies, PEDS is a modular system that enhances the quality of power for utility customers and also delivers energy into the utility system by serving as a distributed generation controller and power conditioner. The PEDS is capable of converting power supplied by photovoltaic arrays, battery storage systems, fuel cells, or microturbines into ac power suitable for injection into the utility grid. In the event of a utility outage, the PEDS can also support the local load by running on its internal batteries or its local generation source. In this way, it prevents outages, voltage sags, and other power anomalies from reaching the customer.

The PEDS prototype (see Figure 1) is housed in a weatherproof enclosure, is rated at 125 kVA, and has been designed to operate with 480-volt, three-phase, 60-Hz power, as is commonly found at US commercial sites. It can be easily adapted to fit the power requirements of any location worldwide. PEDS is a three-port

ASSESSING THE RELIABILITY OF URBAN SUBTRANSMISSION NETWORKS

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Concentration of demand for electrical power in urban centers often results in networks which must be assessed for reliability, but which combine features normally associated with either transmission or distribution systems. In the example shown in Figure 1, the network interfaces with the external system at transmission voltages, and delivers to the load centers at an intermediate voltage. (Although the 132

Figure 1.

(continued on Pg. 3)
**FIRST PED OPERATIONAL**  
*(continued from Pg. 1)*

device from the perspective of power flow (see Figure 2). During normal operation, PEDS conditions the utility line voltage and feeds the conditioned power to the connected customer via its load output port. It also simultaneously converts dc power when available from the PV array (or other dc source) to ac and delivers it to the load output port. If the load is less than the power being produced by the PV array (or other dc source), then the surplus is exported to the utility system via the utility interconnection port. For power quality applications, the system can detect a disturbance and isolate the load from the utility system in less than 1/4 cycle, and then provide up to 5 minutes of outage ride-through capability at rated load. The PEDS is also designed to start and control an optional auxiliary generation device in applications where extended outage ride through is desired.

**THE MOTIVATION BEHIND PEDS IS DISTRIBUTED GENERATION**

While distributed generation generally costs more on a $/kVA basis than bulk generation, it has many advantages that can offset its additional cost. Strategically located distributed generation extends the capabilities of the existing T&D infrastructure by deferring the need for new or upgraded transmission lines, substations, and distribution system equipment. It also reduces system losses and helps displace the need to add new central station generation units to meet load growth. Some distributed generators can be cogenerators (using waste heat for other processes) which in many cases can create dramatic energy savings for customers while reducing pollution and greenhouse gas emissions. Other factors making distributed generation attractive include utility deregulation, the difficulty in obtaining permits for new bulk generation and transmission facilities, and the decreasing cost and environmental benefits of some distributed energy technologies. While these factors make the decision to use distributed generation easier, traditional T&D support economics have not, until very recently, favored it enough to cause a widespread move in this direction. One exception to this is cogeneration applications above 5 MW where there has been a fairly widespread movement among industrial facilities in that direction during the past 10 to 20 years. But for most other applications (for example, the PEDS size range of 50 to 500 kVA) distributed generation is still usually not the lowest cost option. All of that is now changing due to developments in microturbines, fuel cells, photovoltaics, and other sources and over the next 5-10 years a rather large movement towards distributed generation is expected.

The objective in developing PEDS was to further increase the benefits of distributed generation by combining the power quality features of a UPS system with utility support benefits obtainable via distributed generation all in a package compatible with various DG energy sources. This combination is expected to significantly increase the economic payback of distributed generation projects, especially under emerging deregulated utility scenarios, making many more of them viable now, not 5-10 years from now.

**PEDS TEST PROGRAM**

The PEDS system began photovoltaic power production this summer at a site located near Albany, New York. The PV site, whose construction was managed by AWS Scientific, Inc. for Niagara Mohawk Power Corporation, has 120-kW dc of solar array that is connected to the PEDS unit. Power output from the PEDS is then fed into a local distribution feeder at 13,200 volts (a 480 volt to 13.2 kV step up transformer bank is used to convert the PEDS output voltage to a level suitable for the feeder). The PEDS contains its own internal protection relay package to trip the unit off-line should a problem develop.

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**Figure 1.** Photograph of PEDS installed at the field site.

**Figure 2.** PEDS is essentially a three port device from the perspective of power flow. The optional generator could also be connected to the dc port if the output can be filtered and converted to dc.
ASSESSING THE RELIABILITY  
(continued from Pg. 1)

kV system shown here is radial, it could easily be meshed as well.) At each load center, the 132 kV line is tapped, and voltage is stepped down to distribution levels. The 132 kV network is designed as a redundant pair of circuits and the taps can connect to either circuit. The taps are really distribution substations, and are designed to those standards, including provisions for transferring to the other circuit and connecting backup transformers. Hence, we have a prototypical urban subtransmission network.

How does one assess the reliability of such a system?
This was the basic question addressed in a recent study by PTI's affiliate in Pretoria, South Africa, PTI-NET. The assessment method contained a number of key considerations:

- Availability of the external supply
- Size and availability of local generation
- Capability to switch load to alternative circuits of the 132 kV network
- Various designs in use for the 132/11 kV substations
- Success rates and time delays for switching at the distribution substations
- Failure rates for circuit breakers
- Frequency and duration of outage events on the 132 kV lines

Overall, the assessment needed to quantify the impact on customers of subtransmission system unreliability, in terms of unserved energy and cost.

THE APPROACH

To meet the assessment objective, a two-part approach was applied:

1. Identify the reliability characteristics of the various distribution substation designs in order to model them in a meshed network power flow
2. Assess the reliability of the 132 kV system, incorporating the substation design characteristics, with respect to probability of forced outages, success rates for switching, and circuit current and voltage conditions

The matter of reliability characteristics for substations was addressed using the Substation Reliability Assessment (SRA) add-on module in PTI's TPLAN software package. This package allowed simulation of multiple contingencies due to forced outages, stuck or misoperating breakers, and maintenance. It provided for a more detailed model of substations than network analysis tools would allow. An example of one type of substation evaluated is shown in Figure 2.

This Type A substation configuration is currently the most prominent in the Pretoria Metro system. The substation has three load transformers, TA, TB, and TC, and a backup transformer, TR. Transformers TA, TR, TB, and TC are connected to Line 1 or Line 2 via the 132 kV busbar in a manner that will balance the load between Lines 1 and 2. Line 2 is therefore not regarded as a backup for Line 1 and vice versa.

In the case of a 132 kV line fault, the line protection relay sends an intertrip signal that opens the remote 132 kV line breakers. Supply is restored through remote switching of the 132 kV line or bus coupler circuit breaker.

In the case of a transformer fault, the transformer's 132 kV and 11 kV breakers will trip and clear the fault. This also initiates a chop-over sequence (transfer of connection to an alternate source such as 138 kV circuit or backup transformer via automatic actions) comprised of the following: Five seconds after the breakers trip, the 11 kV bus coupler closes, restoring supply to the load via TR. The reliability of the chop-over sequence was found to have a significant impact on the overall reliability of substation design. A successful chop-over assures that load curtailments will last no more than 5 seconds for single con-
The probability of a prolonged load curtailment due to a transformer fault is thus the net product of (a) the probability of a single contingency event involving any one of transformers TA, TB, and TC, and (b) the probability of a chop-over failure.

After SRA evaluation, it was determined that for this substation configuration the frequency of load curtailments with successful chop-over is 0.0034 occurrences per year. Note that even with successful chop-over, there is still a probability of load curtailment due to double contingencies and breaker failures. The frequency of load curtailment is quite small, indicating a highly reliable substation design. However, if unsuccessful chop-over is assumed, the frequency of load curtailment increases to 0.18 occurrences per year, equivalent to a substation with no backup transformer. The actual substation reliability is between these two frequency values, and is a direct function of the success rate of chop-overs.

The SRA results suggested an appropriate model for network analysis with power flows. Basically, this model involved:
1. Explicitly representing each of the transformers, including the backup transformer
2. Adding a trip sequence which activates the backup transformer for outages of a load transformer
3. Applying corresponding outage statistics to each transformer
4. Applying double contingency outage statistics to failures of any two transformers at a time

This model was then implemented in PTI's TPLAN package. TPLAN is a power-flow-based reliability-assessment program which can simulate trip events and multiple contingencies, and can calculate unserved energy indices. It can also reflect the variation in load by approximating the load duration curve, as shown in Figure 3.

**APPLICATION**

The procedure and analytical tools allowed a detailed assessment of reliability in terms of customer impact costs. Specifically, it was possible to calculate the network reliability in terms of unserved energy under the following assumptions: that chop-over is achieved within 5 seconds (correct automatic action), within 15 minutes (via SCADA system), and within 40 minutes (operator action). Combining the unserved energy under these assumptions with the probability of the chop-over sequence produced a composite measure that more realistically reflected customer impact of unreliability. The measure had an additional characteristic as well: the unserved energy could be broken down into individual customers at the 11 kV substations. This characteristic allowed for the application of damage cost functions (cost per duration of outages specific to each customer), and produced an effective measure of unreliability.

Furthermore, the use of network models allowed the comparative assessment of network reinforcements and their effects on the cost of unreliability.

**CONCLUSION**

Using both SRA and TPLAN, PTI-NET quantified the unreliability of the subtransmission system for Pretoria Metro in terms of cost of unserved energy. This included a breakdown of the costs into unreliability of individual components — lines and substations — as well as the impact of equipment reinforcements. The analysis consequently provided a useful guideline for bulk infrastructure investment by relating the capital cost to the utility and the cost of unreliability to its customers.

**ATTENTION: INTERNET USERS**

This and all future issues of the PTI newsletter can be found on our home page:

www.pti-us.com
PTI has recently released Version 1.0 of a new analysis program, PSS/VIPE™ (Power System Simulator for Visual Power EngineRing). PSS/VIPE™ is an off-line power systems analysis program that combines exceptional ease of use with powerful analysis algorithms. It has been in use on a prototype basis for over a year in organizations ranging from utilities, both in the UK and USA, to military and civilian ship builders as well as to consultants and cogeneration plant operators.

**MOTIVATION FOR A NEW PRODUCT**

PSS/VIPE™ was conceived to meet a new market for PTI: the marine, industrial, and small utility market where, typically, power systems are small and the technical requirements are high. Typical power system analysis varies in these markets from rapid one-off to regular system analysis. The main requirement was ease of use within a single environment for power system analyses.

Analysis capabilities for load-flow, featuring induction machines and circuit breakers, as well as time-decremented faults and dynamic stability, were identified for the first release. On-going developments include modules for harmonics, protection and coordination, transmission line constants, and low-voltage dc.

PSS/VIPE™ is one of the new generation of PTI software products which address specific market needs through the use of common software modules. Where necessary, existing common analysis capabilities were further developed to meet target user needs. When PSS/VIPE™ development began, a new set of one-line diagram graphic routines known as Slider had already been completed. Meanwhile, core analysis engines were nearing completion. These engines are now known as PSS/Engines™, and they are designed for use both internally and externally in third-party applications such as Geographic Information Systems (GIS). These common modules were being combined to develop PSS/ADEPT™, the successor to PTI’s distribution analysis product PSS/UT™, and the same approach was applied to PSS/VIPE™. By using core graphics and analysis engines augmented with a product-specific user interface that is driven by market requirements, PTI has created a market-focused product which benefits from use of existing, reliable, software components.

Full integration of this new product with PTI’s existing products was also a requirement. PSS/VIPE™ can import PSS/E raw data files and automatically construct a diagram (at present for systems up to 200-300 busbars) as well as export files in the PSS/E format including files required for dynamics. Additionally for the UK market, PSS/VIPE™ can import networks from the university-developed package, IPSA. This feature has enabled embedded-generation suppliers to use PSS/VIPE™ to provide PSS/E files of their network to the local utility, while simultaneously allowing them to migrate to PSS/VIPE™.

Detailed reports are available for load-flow and fault-level results as well as input data. Each of these reports can be saved as a file or copied straight into a spreadsheet or word processor. Links for data sources using ODBC have also been added, allowing users to extract data from their own corporate database using ODBC data-source drivers.

Network diagrams are easily created using default data, which can be altered and saved for future use. Options such as Copy and Paste...
network items enable large networks to be constructed or altered with ease. PSS/VIPER incorporates state-of-the-art, fully Microsoft®-compliant architecture which, combined with the use of object oriented C++ language throughout, represents the latest in software development technology with assured longevity.

LOAD FLOW

Internally, the PSS/Engines use physical values such as ohms and volts, but PSS/VIPER represents the power system data to the user as either traditional per-unit on system base or per-unit on rating for each item. It also provides an induction motor model that can be defined as either single- or double-cage models. Rotor data can be either inner/outer or start/run; seamless transition between the two types of data is provided. Power consumed by the induction motor can be calculated from either side of the motor shaft, i.e., mechanical or electrical power.

FAULT LEVELS

In 1988 a European Standard for fault level analysis was issued, known as IEC909. At the same time, the UK electrical industry was starting the process of privatization and one issue was legality relating to compliance with standards. If IEC909 was applied, then various switchgear used in the system could be considered to be over-stressed and would have to be replaced. This was due to the pessimistic techniques used — rightly so for what IEC909 was intended for: an engineer’s guide to fault calculation using a calculator. The aim of the standard was to establish a practical and concise procedure yielding conservative results with sufficient accuracy.

The Electricity Association established a committee in 1990 whose report, G74, recommended a number of techniques to enable a more accurate fault level calculation. These techniques addressed aspects such as break duties, which are to be calculated at the time of clearance and to include induction motor contributions. It also recommends that saturated synchronous machine reactances be used where appropriate.

PSS/VIPER supports the G74 standard, allowing the user to specify the time after the fault has occurred and use this for the fault currents to be evaluated. The type of fault current evaluated is specified by the user who can select from Asymmetrical Peak, Asymmetrical RMS, or Symmetrical RMS values.

Fault types can be balanced or unbalanced and the fault calculations include the contributions of induction machines (single or double cage) and synchronous machines. Using this information, circuit breakers in the system can be checked for over-stress. In the near future we will allow for coloring on the diagram to show over-stressed breakers. The user can also enter saturated synchronous machine parameters on the property page for each synchronous machine.

DYNAMICS

PTI has extensive experience in the development of software for dynamic system analysis which has been embodied in the PSS/E product. PSS/VIPER uses the dynamics-analysis section of PSS/E as a calculation server to provide dynamic analysis of balanced three-phase power systems. PSS/VIPER provides a simple user interface to this powerful dynamics-analysis capability. Based on the parameters specified through the PSS/VIPER user interface, the program generates data-input files describing the network for the PSS/E Dynamics module which is then automatically started in the background to perform the analysis. Results are returned for display using the PSS/PLT plotting program. Alternatively, experienced PSS/E users can generate the data files from PSS/VIPER and then drive PSS/E manually. Only "table"-driven dynamics models are available in PSS/VIPER, user-written models that require recompilation of PSS/E dynamic files are not supported.

RELEASE

The recently released version 1.0 of PSS/VIPER provides load-flow, short circuit, and dynamic simulation. Later versions will include modules for harmonics, protection and coordination, transmission line constants, and low voltage dc.

With PSS/VIPER, PTI has been able to draw on available technology, and augment and focus these tools to address specific needs of a new market. Users gain the advantage of a tool styled to the needs of their industry, combined with access to robust and powerful analysis capabilities which have benefited from the experience of application in other market segments.

CONTACT DETAILS

For a demo CD, trial copy, or further details, contact Mike Edmonds, Product Manager, Telephone +44 (0)1565 650388, Fax +44 (0)1565 750387, or E-mail at mj.edmonds@pti-us.com.
ENGINEERS FROM EGYPTIAN ELECTRICITY AUTHORITY ATTEND CUSTOMIZED TRAINING SESSIONS

PTI recently had the pleasure of conducting two six-week training sessions for engineers from the Egyptian Electricity Authority at our offices in Schenectady, New York. In all, twelve engineers attended the training which was funded by USAID and administered by the Institute of International Education (IIE). The curriculum for each training session, Substation Design and Transmission Line Design, respectively, was customized to the client's specification and included presentations by PTI, NYSEG, and several other industry leaders. Visits to New York City, Niagara Falls, and Washington, DC, were cultural highlights of the study tour.

Left to right standing: Taoufik Ben Ammar, Interpreter, Mamdouh Abdel Fattah Mohamed Hatem, Mona Aly Abd Alla Haggag, Mohamed Anwar Mohamed Hassanin, Ehab Fawzy Mahmoud Ibrahim Khamis, left to right sitting: Hekmat Abdel Rahman Selim El Sebaie, Nahed A. Heggi, Fayza Hamdy Mohamed Anwar.

RECENT PUBLICATIONS

For further information on any of the following publications, please contact:

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Telephone (518) 395-5047  •  Fax (518) 346-2777  •  jm.aviles@pti-us.com

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<tr>
<td>H.W. Zaininger (PTI) and B. Parsons (National Renewable Energy Laboratory)</td>
<td>Integrating Wind Turbines into the Orcas Island Distribution System: Study Results</td>
<td>April 27-May 1, 1998 - Presented at the American Wind Energy Association, Windpower '98, Bakersfield, CA</td>
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L.O. Barthold, Y.A. Kazachkov, et al. (Trans-Asia Power Transmission/PTI), V.M. Boroveki, S.V. Kuimov, and A. Svitschenko (Irkutskenergo) | Privately Financed Transmission — The Trans-Asia Example | September 22-26, 1998 - Presented at the Conference on Eastern Energy Policy of Russia and Problems of Integration into the Energy Space of the Asian Pacific Region, Irkutsk, Russia


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power technology
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Schenectady, N.Y. 12301-1058
Telephone 518-395-6000
FAX 518-346-2777

Address Service Requested
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<td>Modifying &amp; Maintaining Structures and Conductors in Transmission Line Uprating - Joint Course with EPRI Power Delivery Center</td>
<td>Jan. 19-21</td>
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<td>Distribution Lightning Protection</td>
<td>Mar. 3-4</td>
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<td>Improving Reliability of Large Interconnected Systems</td>
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<td>PSS/E - Introduction to Dynamic Simulation</td>
<td>Sept. 27-Oct. 1</td>
<td>$1725 - Las Vegas, NV</td>
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<td>Power Distribution Systems</td>
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<td>Power System Analysis</td>
<td>May 4-6</td>
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<td>Power Distribution Systems Economics</td>
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<td>Advanced Transmission Planning with Modern Network Analysis Tools (PSS/E, TPLAN &amp; OPP)</td>
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<td>Real-Time Thermal Monitoring and Rating of Transmission Circuits</td>
<td>Oct. 28-29</td>
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<td>Distribution System Losses</td>
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<td>PSS/E - Advanced</td>
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<td>PSS/E - IPLAN</td>
<td>Oct. 13-15</td>
<td>$1510 - Reno, NV</td>
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<tr>
<td>PSS/U and PSS/ADEPT (3 or 4 day version)</td>
<td>Oct. 19-21 (Oct. 22)</td>
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<td>Fundamentals of Overvoltage and Insulation Coordination</td>
<td>Nov. 2-4</td>
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<td>Underground Cable Systems: Principles and Analytical Techniques - Joint Course with Power Delivery Consultants, Inc.</td>
<td>Nov. 4-5</td>
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<tr>
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<td>Reliability Assessment Methods for Transmission Systems</td>
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<td>Power Plant Performance and Monitoring</td>
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<td>Nov. 29-Dec. 3</td>
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<tr>
<td>Distribution Planning &amp; Reliability</td>
<td>Dec. 6-10</td>
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<tr>
<td>Photovoltaic Systems and Applications</td>
<td>Dec. 15-17</td>
<td>$1510 - Phoenix, AZ</td>
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**SPECIAL COURSES OF STUDY**

Conducted at Power Technologies, Inc. Corporate Headquarters, Schenectady, NY

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<tr>
<td>Power Distribution Systems Engineering - A Four Week Course of Study - April 26 – May 21</td>
<td>This course offers a comprehensive curriculum in distribution system engineering including system design, protection, equipment applications, economics, and distribution system planning. Participants will have the opportunity to examine new technologies and become familiar with the latest industry trends to increase system efficiency and reduce costs. Distribution engineers wishing to broaden their technical skills and improve their ability to meet the challenges of today's utility environment will find this course valuable.</td>
</tr>
<tr>
<td>Transmission Line Design and Upgrading - A Four Week Course of Study - May 10 – June 4</td>
<td>This training program will allow both experienced and novice transmission line design engineers to review and upgrade their skills and learn how to apply the latest materials and design techniques. The course will cover both design of new lines and upgrading of existing lines over the full range of HV and EHV voltage levels.</td>
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<tr>
<td>Power System Transmission Planning &amp; Analysis - A Six-Week Course of Study - September 13 – October 22</td>
<td>A comprehensive approach to gaining the practical knowledge necessary to effectively use and apply power engineering analytical tools and methodologies in transmission system planning. The course includes sessions on planning concepts and principles are combined with intensive “hands-on” use of PTI's PSS/E program, application workshops, and study tours of utility sites for a broad-based learning experience.</td>
</tr>
</tbody>
</table>

**INTERNATIONAL COURSES**

<table>
<thead>
<tr>
<th>COURSE TITLE</th>
<th>TUITION</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe – Manchester, United Kingdom</td>
<td></td>
<td></td>
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<tr>
<td>Power System Dynamics</td>
<td>Call Administrator</td>
<td>April 12-16</td>
</tr>
<tr>
<td>Introduction to PSS/E Power Flow and Steady-State Analysis</td>
<td>Call Administrator</td>
<td>Oct. 5-7</td>
</tr>
<tr>
<td>Introduction to PSS/E Dynamic Simulation</td>
<td>Call Administrator</td>
<td>Oct. 26-28</td>
</tr>
</tbody>
</table>

**Cancellation Policy**

Occasionally, unforeseen events or insufficient enrollment may necessitate the cancellation of a course. If a course is canceled, PTI will attempt to notify each registrant no later than 14 days prior to the start of the course. PTI is not responsible for any cancellation charges imposed by airlines, hotels or travel agents.

**Registration Note**

It is recommended that you register one month before any course. Registrations will be accepted within the month time frame but space may be limited.

For further information on courses or registration

In the United States contact:

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