INTERACTIVE PRODUCTION COST PROGRAM UPDATE

M. A. Sager
Senior Engineer

Four new, major features have been added to the Interactive Production Cost Program (IPC) since its description in the January, 1978 issue of the PTI Newsletter. These features allow utility planning and operating engineers to: 1) model co-generation units supplying both steam demands and electrical energy, 2) develop reports of hourly marginal operating costs required by the Public Utility Regulatory Policies Act of 1978 (PURPA), 3) model direct load management involving energy payback characteristics such as encountered in water heater and air conditioning load control, and 4) accurately model complex sales.

Co-generation

The co-generation units modeled are single extraction units. By-pass valves to permit the supply of steam during periods when the turbine generator is on forced outage can also be included in the model. When both the boiler and the turbine generator are in service, steam demands are supplied through extraction.

Additional data required to describe co-generation unit types, besides the normal data required to describe non-extraction thermal unit types, include a boiler outage rate and the fuel input required to obtain the steam demands for given process steam demands plus the electrical outputs defined for the basic thermal unit. Figure 1 illustrates the required type of fuel input versus the electrical output data needed.

The IPC simulation of co-generation unit operation requires a forecast of the extraction steam demand. IPC produces the monthly and annual reports showing the fuel costs for the co-generation units in two parts, the fuel costs associated with the steam dispatch and the fuel costs associated with the electrical dispatch.

RESEARCH ON DC CONVERTER REPRESENTATION

B. K. Johnson
Analytical Engineer

Studies are underway at PTI using the Digital DC Simulator program (see October 1978 PTI Newsletter) to establish the relative accuracy of various assumptions commonly used in load flow and stability calculations. Widely used practice is to set the “commutating reactance” equal to converter transformer reactance, the commutating voltage equal to the ac voltage on the primary side of the converter transformer and to consider the commutating resistance as zero. This practice is based on the assumptions that the ac-side harmonic currents and voltages introduced by the finite commutation time do not propagate into the ac system because of filtering and cancellation effects.

The resolution of results obtained with the digital simulator program, coupled with the ability to process wave shapes using Fourier series, provides the means to establish effects of ac- and dc-side filtering on converter performance, with particular reference to reactive power requirements.

The validity of various commonly used assumptions in representing converters in fundamental load flow and stability calculations is being researched with this powerful simulation tool and hopefully detailed results will be published in the near future.

Another area of HVDC system modeling also deserves careful attention with respect to its accuracy, i.e., representation of firing angle control dynamics of converters. DC converters are controlled by feedback loops nested at several levels. The innermost loop controls valve firing time delay to achieve a required value of current, dc voltage or commutating margin angle. These required values may in turn be controlled by “outer loop” which implement voltage-sensitive current limits, power control, frequency control, system stabilizing control or other features. The dynamics of the inner control loop are so fast that, for power system stability calculations, it is reasonable to assume that they respond instantaneously to outer control or changes in the ac grid system. Studies using PTI’s Digital DC Simulator Program confirm the acceptability of the assumption. To show the response characteristic of dc controls and to show the applicability of fundamental frequency calculations using the multiplication factors describ-
IPU UPDATE (continued from page 1)

PURPA Reports

PURPA requires reporting hourly marginal energy costs for a "typical weekend day" for each month of "the reporting period and for each month of the next five years." In addition, if the utility has calculated marginal energy costs for any other hours the information must be supplied upon request.

Activity PURP of the IPC program calculates and reports marginal operating costs, total expected operating costs and the probability of a capacity deficiency for each hour or bi-hour time period. In addition, the average expected marginal operating costs, the total expected operating cost and probability of a capacity deficiency are calculated and reported for each day of a month and for each month of the next year. This information must be reported for each day of a month and for each month of the next year. The marginal energy cost for any hour is defined as the increased cost of fuel and variable operation and maintenance that would be incurred due to the production of one additional kilowatt-hour electrical energy. The total expected operating costs are the costs that are expected to be incurred by the generation system in order to serve the utility load including the cost of fuel that would be incurred due to the operation of co-generation units dispatched to meet a system steam requirement. This cost does include the incremental fuel cost incurred by co-generation units dispatched to meet a steam demand plus the expected cost of fuel under the assumption that the co-generation units are being dispatched to meet extraction steam requirements and that electrical output is at incremental cost.

Plots of expected costs and marginal costs for various thermal unit commitments and loads are shown in Figures 3 and 4.

Load Management

The LMGT activity of the IPC program allows the study of the effects of daily, direct load management control of appliances such as water heaters and air conditioning in terms of the operating cost benefits that can be obtained. The load management simulation uses a linear programming algorithm that minimizes daily production costs while observing operating constraints and payback requirements. The data required to simulate load management includes composite load curtailment/payback characteristics of the load management devices being studied. Curtailment/payback characteristics may be different for different times of a day to simulate the variation in the amount of controllable load by hour of the day and day of week. Data are also required to describe these variations.

Unit Sales

The IPC logic has been expanded to model true unit sales contracts and allows the utility planner to accurately study the economic effects of these unit sales. The unit sale which has been modeled is one where a given constant percent of the available unit is to be dispatched and sold to the purchaser. When the sale unit is on maintenance there is no sale and the hourly sale is reduced due to partial and full outages of the sale unit. If revenue rates are supplied as part of the data base, revenues from the sales will be calculated and separately reported. Total gross system production costs will be reported as well as system production costs net of sale revenues.

IPC Philosophy

As indicated in the earlier PTI Newsletter IPC is structured such that new simulations, or variations on existing simulations, can be easily incorporated. The set of enhancements described in this article is one example but should not be considered the only way these system operations can be simulated. For example, the unit sale described here is for a single type of unit sale. There are other unit sale types and the simulation of these sales, once they are described, can be easily added to the IPC simulation array. Likewise, alternative output formats can be easily designed and integrated with existing outputs.

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**Figure 2**

SAMPLE OUTPUT FROM PURP ACTIVITY

The marginal energy cost for any hour is defined as the increased cost of fuel and variable operation and maintenance that would be incurred due to the production of one additional kilowatt-hour electrical energy. The total expected operating costs are the costs that are expected to be incurred by the generation system in order to serve the utility load including the cost of fuel that would be incurred due to the operation of co-generation units dispatched to meet a system steam requirement. This cost does include the incremental fuel cost incurred by co-generation units dispatched to meet a steam demand plus the expected cost of fuel under the assumption that the co-generation units are being dispatched to meet extraction steam requirements and that electrical output is at incremental cost.

Plots of expected costs and marginal costs for various thermal unit commitments and loads are shown in Figures 3 and 4.

**Figure 3**

EXPECTED OPERATING COST VS. LOAD FOR THREE COMMITMENTS OF UNITS

**Figure 4**

MARGINAL OPERATING COST VS. LOAD FOR THREE COMMITMENTS OF UNITS
ed above, the transient stability program, PSSE, was used to simulate a system with parallel ac and dc transmission (see Figure 1). A 12-cycle ac system fault near a dc line was the disturbance. The same case was simulated using PTI's Digital DC Simulator Program which represents the three-phase system at the differential equation level and the firing and extinction of each dc converter thyristor. Figures 2 and 3 are plotted results from the two simulations showing real and reactive power at the rectifier and inverter. They show excellent agreement between the detailed and fundamental frequency simulation. These studies illustrate the need for continuing efforts to assure that computer models of HVDC terminals are both comprehensive and accurate.

**UNISYSTEM — PTI's UNIFIED SOFTWARE DEVELOPMENT SYSTEM**

**R. J. MILLS**  
Senior Engineer

PTI is now marketing a new package of software development tools called UNISYSTEM. The package is directed at improving software quality, manageability, documentation and productivity during the development phase. UNISYSTEM is especially applicable to development projects requiring the close coordination between a group of team members, and for real-time software projects which handle large numbers of data items and which might require several parallel computers. Organizations which strive for inter-project uniformity of development and documentation approach, structured top-down coding practices, and independence from any one computer family can also benefit from UNISYSTEM.

UNISYSTEM evolved from experience gained in power plant operator training simulator projects. The development of the process models for such a simulator is a ponderous task. Each simulator requires development of more than one hundred closely interacting programs, requiring the efforts of 6 to 12 people and a total effort of tens of man years. The scope is such that 20,000 or more named variables must be correctly accounted for, and 40,000 or more inter-program interfaces must be successfully coordinated. Complications of the operating environment such as real-time operation, and multiprocessor configurations further compound the potential for confusion. In addition, design details of the simulated plant change requiring near-continuous revision and updating of the model programs. Software management problems in these simulator projects are not unique, just acute.

The scope and size of the simulator software task demands much discipline and focuses much attention on the quality of the coding, documentation and project team coordination. PTI has always felt that the best results are achieved when engineers with process knowledge write the model programs directly. In many organizations, these two goals are considered mutually exclusive, and that high quality software results only when engineers submit their design specifications to expert programmers. Engineers themselves tend to be actively disinterested in tending to the "system" or non-engineering aspects of software development. UNISYSTEM attacks this problem by preserving much of the "system" details for a real time environment, automating much of the tedious bookkeeping and cross-checking chores, and providing language extensions which make structured top-down design natural rather than arduous. The work remaining to produce a finished product can then concentrate more on the engineering aspects. The process of composing, testing and documenting programs is more engineering oriented and easier to use than most program development facilities.

UNISYSTEM includes four key programs, all of which are tools designed to support the development of real time application software. In one sense, UNISYSTEM provides a shell, or a special purpose operating environment which operates within the framework of the host computer's standard operating system. These programs relate to each other and to the applications programs through a central data base file, which is built and maintained by UNISYSTEM itself. This file contains descriptions of the data and the applications programs which use the data but not the applications data itself. The file also contains documentation information on each symbol, plus various cross-reference and mutual-interdependency information used for software management. UNISYSTEM's data base should not be confused with Data Base Management Systems (DBMS), now in widespread use. Its purpose is entirely different.

The four key programs in the UNISYSTEM package are

- **UNITRAN** — a translator program which automatically establishes the links between applications programs which reference the same process quantity by name. Applications programs may be written in either FORTRAN or assembly language and output from UNITRAN is sent to the host system's standard FORTRAN compiler or assembler. UNITRAN also incorporates the FLECS extensions to FORTRAN which make structured top-down design easier (see PTI Newsletter, Issue 14).

- **UNIDATA** — a program used to create, query or modify the information in the data base. Its most significant feature is that it allows such data base manipulations to be done both interactively and incrementally. Interactive operation requires that manipulations be fast and that the mode of interface be clear and easy to use for engineers. Incremental means that additions, deletions or modifications to the data base can be executed one item at a time, and at interactive speeds. There is no need for redifinition of the entire data base, and no postponement of secondary processing or garbage collection until a later time.

(continued on page 4)
PTI GOES TO THE DOGS!

Jay A. Williams
Senior Engineer

Two demonstrations have recently been conducted by PTI to evaluate the ability of trained tracking dogs to locate oil leaks from buried high-pressure oil-filled cable systems. This novel approach is a part of an EPRI/PTI project (EPRI RP7689-1) to develop rapid and accurate methods for locating leaks from buried cables.

A dog’s olfactory sense is several orders of magnitude more sensitive than a mass spectrometer for detecting trace amounts of many compounds; for example, dogs are commonly used to detect small amounts of hidden drugs and explosives. PTI awarded a subcontract to Guardian Training Academy in Canada who had extensive experience in training dogs to detect leaks from buried natural gas pipelines. Samples of cable oil and a tracer odorant were given to the trainer. Over a period of several weeks he taught two German Shepherds, who had previously been trained as tracking dogs, to respond to successively smaller concentrations of the oil, at successively lower depths of burial.

The dogs successfully indicated the location of four buried leaks at PTI’s Saratoga R&D Center a dozen times during an initial demonstration in January. The odorant was repulsive to dogs, even at concentrations as low as a part per million, so subsequent training was done only with cable oil.

The Saratoga environment had few distractions and a low background level of oil so a second test was arranged for New York City streets in March. Con Edison staged small leaks in three locations: under grass on a right-of-way, under a city street, and in a manhole. After initial problems due to heavy traffic, both dogs performed well and indicated all three leak locations. There were no false indications either at Saratoga or in New York City in spite of the visible presence of motor oil and gasoline on the street surface.

In view of these encouraging results, further work will be done to have the dogs taught to track over longer distances and to be undisturbed by city traffic. A second subcontract is being given to the Southwest Research Institute to investigate the ultimate capabilities of dogs to detect trace amounts of cable oil through various backfill materials and pavements. As with any of the leak location methods being developed by PTI, the dogs are available on a trial basis for use by utilities searching for leaks from buried cable systems.

UNISYSTEM (continued from page 3)

- UNIREX — UNISYSTEM’s Run Time Executive. It provides the functions of an application executive program for both off-line and real-time operation. UNIREX also provides symbolic debugging facilities, statistic gathering and evaluation and high speed data capture.

- UNIPILOT — retrieves data captured at high speed by UNIREX and prepares plotted or tabular reports suitable for output on terminals, line printers and printer/plotters. UNIPILOT can operate after-the-fact to prepare reports on data captured in real-time. UNIPILOT can also prepare single reports combining data from several UNIREX sessions.

These four key programs are supplemented by a number of UNISYSTEM compatible programs. UNIDRAW — allows presentation of calculated data directly on drawings of arbitrary complexity and format, (for example turbine model results on a turbine heat-balance diagram, or test program output directly on a program flow chart). UNIDIS — a color CRT display/display-compiler package which resides in an intelligent CRT terminal, (i.e. not in the host computer), and which has access to all symbols described by the data base. Additionally, three applications packages, specifically designed for use in operator training simulators are available. UNITEACH — provides the interface for the simulator instructor. UNIFLOW — a therapist-hydraulic load flow which models piping systems throughout the plant in real-time for simulator applications, (see PTI Newsletter, Issue 18). UNIVOLT — an electrical load flow similar in purpose to UNIFLOW.

UNISYSTEM is designed to support development of real-time applications. Accordingly, one of the design criteria was that UNISYSTEM must not add any speed or size overhead to the applications programs. Another important criterion was that UNISYSTEM should promote computer independence. UNISYSTEM itself is written to conform with the ANSI X3.9-1978 standard FORTRAN. Therefore UNISYSTEM programs are transportable to any suitable computer supporting a standard conforming compiler. Present plans call for installation of UNISYSTEM on PRIME, DEC VAX, NORD, PERKIN-ELMER and SEL computers. However, to achieve true portability, it is also necessary for the applications programs themselves to avoid using vendor-proprietary extensions to the computer’s standard software. UNISYSTEM does not force such discipline, but it does assist by providing desirable language extensions and features as an integral part of the UNISYSTEM package. Applications programs developed using these extensions are then portable to any computer which can host UNISYSTEM.