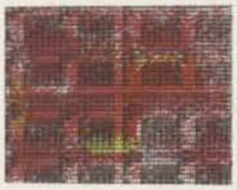

# TRICE

pb Packard Bell Computer

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# HYBRID GP/DDA COMPUTING SYSTEM

*Unparalleled speed and accuracy at incredibly small programming cost.*

*Use TRICE for solving*

- differential equations in real time
- simulation studies including open loop integrations and axis transformations involving trigonometric and algebraic operations

TRICE outperforms both analog and large general purpose digital computers.

Compared to a large scale digital computer for solving problems such as those involving differential equations, TRICE provides substantially reduced setup and execution times with no loss of accuracy. Because TRICE module algorithms are indentical to the mathematical operators, it can be programmed by engineering personnel after a short training period (one customer's engineering staff learned to program TRICE in one morning after reading only a sales brochure). No programming staff is required to utilize the extensive capabilities of this powerful computer, thereby saving many thousands of dollars in programming costs and engineering time. Literally man-years of programming effort are eliminated. The engineer with the problem can communicate directly with TRICE, observe problem solution, change parameter values and/or the mathematical model to obtain the desired results. Control system design studies may be carried out by direct representation of Laplace transforms on TRICE.

One TRICE can do the work of a room full of analog computers while providing flexibility and versatility not possible with such equipment. Consider these advantages offered by TRICE...

- *Open loop integrations to the accuracy of the data*
- *Periodic functions remain stable over any period of time*
- *Fast setup because of complete digital communications at 3 mcs*
- *Analog speed without sacrifice of digital accuracy*
- *No scaling computations required as these are performed automatically*
- *Automatic verification of all entered data*
- *Absolute repeatability*

¶ *Real Time Computation* – TRICE, the world's most advanced digital differential analyzer, permits real time computations at speeds previously associated only with analog computers. For the first time, the accuracy and repeatability of digital computation can be applied to dynamic system problems such as space vehicle simulations, multibody orbit problems, and axis transformations.

¶ *Hybrid or Independent Operation* – TRICE may be used independently or may be connected to an analog computer or control system as a hybrid system to provide problem solutions where accuracy requirements exceed the limits of analog computation alone. Incorporated in TRICE are special analog to digital converters which provide effective sampling rates of up to $2^{17}$ samples per second. Thus TRICE presents to the analog computer or to the hardware under test the appearance of a continuous medium without the problems of sampled data operation usually associated with conventional hybrid systems employing an analog computer and a general purpose digital computer.

¶ *Engineer Programming* – Problem solution data can be logged automatically in engineering units periodically or based on a problem condition as desired. Because no analog-to-digital conversion is involved in the logging process, no error is introduced as a result of this operation. Digital input and output features such as this mean drastically reduced problem setup and checkout time as compared with analog computers. Combined with analog programming methods which eliminate the need for numerical analysis, the result is faster programming of problems than is possible with a general purpose computer even utilizing automatic programming aids. Since automatic control of TRICE is provided by means of a stored program the number of modes of operation is limited only by the ingenuity of the operator.

¶ *General Purpose Computer* – A basic component of TRICE is the PB 250 digital computer with its inherent power of decision, control, and arithmetic. This solid state general purpose computer can be used independently for engineering and scientific computation in addition to its function as a major control element in TRICE. The PB 250 features microsecond speed, a memory expandable from 2320 words to nearly 16,000 words of storage, wide range flexibility through a large software library, and a comprehensive complement of 59 commands.

Utilizing an input/output control program, the PB 250 provides the operator with a means for communicating with TRICE in engineering units. No scaling is required and thus another source of error common in analog problem setup is eliminated. All data entered into TRICE are verified automatically and a typewritten copy is provided as a permanent record. Rapid programming and checkout allow investigation of many different mathematical modes for a given physical system in a relatively short period of time. Conventional analog plots in XY or strip chart form are provided by means of a plotter operating from the output of a digital to analog converter which provides 14-bit accuracy at analog speeds.

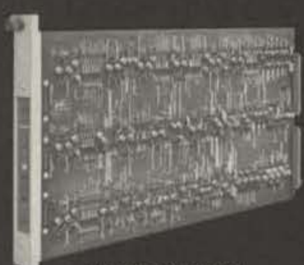
The PB 250 computer also permits hybrid general purpose-DDA computation capability without restriction on the number of channels of communication between machines. All TRICE elements can be accessed by the PB 250 for transfer of data in both directions. The problem of sample data dispersion is eliminated by simultaneous sampling and the presentation of data on the respective channels. Iterative solution of boundary problems is provided by the decision capability inherent in the PB 250 with the partial and selectable modes of TRICE plus the memory capability of the TRICE register.



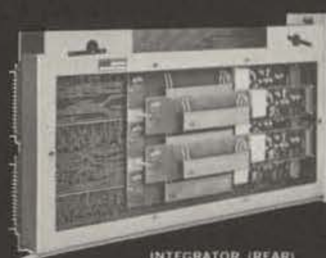
MODEL TC 5108/250 • This unit, having a capacity of 108 computing modules, is an expanded TRICE of the type in use at North American Aviation. MODEL TC 5144 • (not shown) accommodates up to 144 modules including 16 integrators, 4 variable multipliers, 4 constant multipliers, 4 decision servos, 4 ΔY summers, and 4 function units.

# ICE

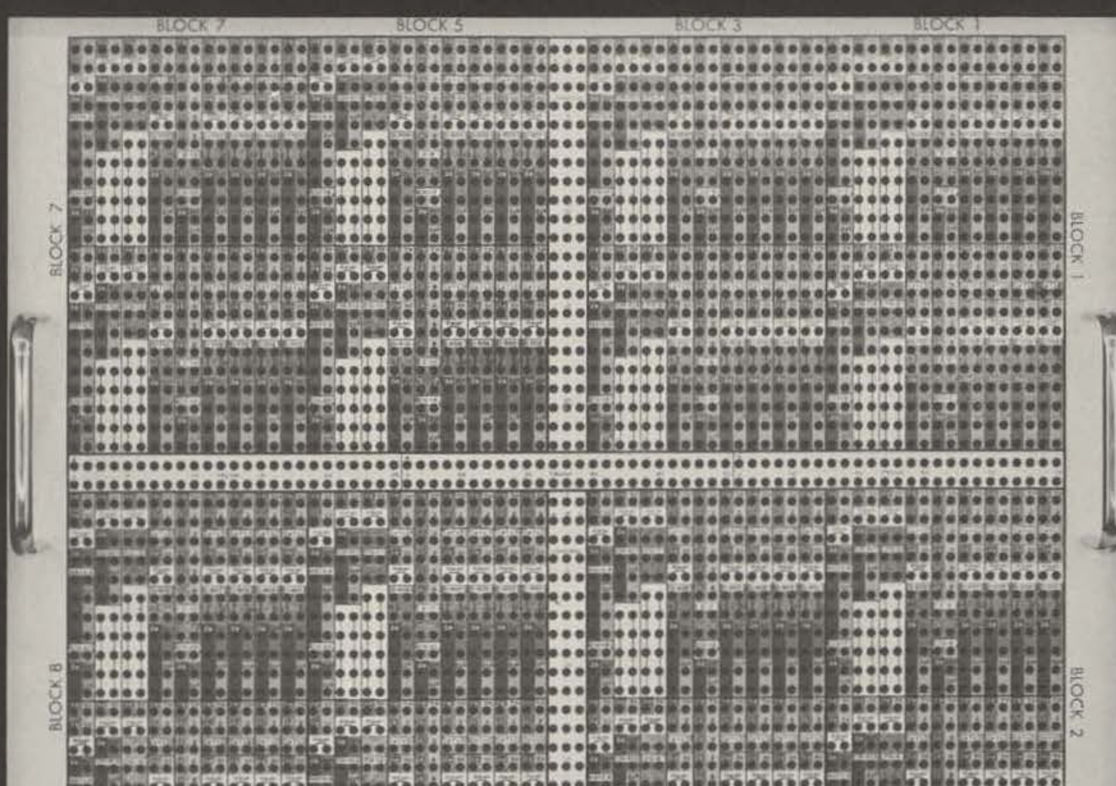
INTEGRATOR • Showing front panel and printed circuit board with mounted components. INTEGRATOR • Reverse side showing mounting of three Model MSR 5 memory modules. PATCH PANEL • Modules are grouped into 8 modular computing blocks. Two blocks correspond to one module bay. PB 250 transfer control lines, TRICE control function inputs and outputs, and trunks are in the center white areas.



INTEGRATOR (FRONT)



INTEGRATOR (REAR)




PATCH PANEL

# DESCRIPTION

TRICE is a solid state digital differential analyzer utilizing binary arithmetic and digital logic operating at three megacycles. TRICE is organized like an analog computer having individual computing elements capable of performing the operations of integration, multiplication, and function generation. These elements are interconnected via an analog type of patch panel to obtain problem solution.

Two word lengths are available as options — 30 bits with an iteration rate of 100 kcs or 24 bits with an iteration rate of $2^{17}$ per second. The maximum usable word lengths are 26 bits plus sign and 20 bits plus sign, equivalent to 8 and 6 decimal digits respectively.

Computation and transfer of information are done on an incremental basis. Two lines, existence and sign, are used to transfer increments between elements. This is referred to as ternary transfer since there are three possibilities of transfer during any iteration period, namely 0, +1, −1. Operational memory, constant, and initial condition storage are provided by magnetostrictive delay lines. These lines with their read-write electronics are packaged as submodules which plug into the computing modules for trouble shooting ease and maintenance by substitution methods.

TRICE is made up of six basic computer elements, namely — integrator, variable multiplier, constant multiplier, decision servo, Y summer, and function unit.

*Integrator* • The integrator performs integration with respect to both independent and dependent variables. The ability to integrate with respect to nonlinear variables makes it much more powerful than its analog counterpart. Three algorithms are available — trapezoidal extrapolative, trapezoidal interpretive, and rectangular and are selectable by patchboard connection with a jumper plug. The integrator has three registers — the I register to store initial conditions, the Y register to accumulate the whole value of the dependent variable $\Sigma\Delta Y$, and the R register to store the least significant half of the product $S_i = (Y_i + dy_i)dx_i$ plus, minus, or zero $1/2\ dy_i$ [sign $dx_i$].

According to the algorithm selected, inputs to the integrator are dx, the independent variable input, and $dy_1$ and $dy_2$, two dependent variable inputs (in the limit as $\Delta$ approaches zero, $\Delta$ is replaced by the differential). The output is dz, equivalent to the most significant half of the R register in incremental form. If the sum of the dz outputs of an integrator is accumulated in the Y register of another integrator it forms the integral $dz = \int y\,dx$. Both signs of dz are available at the patchboard.

*Variable Multiplier* • Variable multiplication can be done by means of two integrators and by means of the identity $duv = vdu + udv$. This operation is done in the variable multiplier thereby eliminating one R register and providing the product output in incremental form.

*Constant Multiplier* • If the dy inputs of an integrator are not used, the number in the Y register remains constant and and the algorithm is $dz = vdx$. In a constant multiplier this is done with the saving of one register by combining the functions of the I and Y register in one unit.

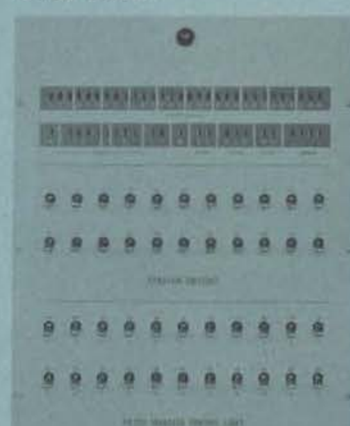
*Decision Servo* • The decision servo is similar to the integrator but has two registers I and Y. It uses two different algorithm servos: $Y \pm 0\ dz = dx$ (sign Y); $Y = 0$, $dx = 0$, and decision $|y|\ 0.5$; $dz = 0$; $Y = 0$, $dz = 0$.

The servo algorithm allows use of the servo as nulling device for implicit function generation. The decision algorithm with the initial condition set in relation to $|0.5|$ is used to generate discontinuities. Selection between algorithms is made by a jumper plug or the patch panel.

*Delta Y Summer* • It is sometimes necessary to sum more than two dy inputs into the Y register of an integrator or servo. The $\Delta y$ summer allows the summation of up to six incremental inputs into the Y register of the particular integrator or servo to which it is connected. This connection is made by means of a jumper plug on the patch panel. The summer is also used with a servo to obtain the sum of a number of incremental inputs in incremental form as required, for example, to form a dependent variable for the dx input of an integrator.

*Function Unit* • A first order approximation is used with straight line segments between breakpoints. Breakpoint spacing is variable. The integrator I and Y register contents can be interchanged by means of a command signal input. If the register contains the current value of slope corresponding to the function of x during the interval between two breakpoints, and the independent variable input is dx the function $dz = f\,(dx)$ is generated. The I register contains the value of the slope corresponding to the next breakpoint interval. On reaching the breakpoint the registers are interchanged by the command signal within one iteration period, updating the slope value.

The function units serve to store the current and next value of the breakpoint interval and provide the interchange command signal. Its input is also dx. It also provides a signal to the PB 250. The PB 250 is used to store the breakpoint intervals and slope values for a number of function units. The signal to the PB 250 indicates whether the current value of x is less than or greater than 1/2 the breakpoint interval and whether the next breakpoint interval and slope values currently stored in the function unit and integrator are the next lower or higher. Based on these signals the "next" values are updated if required. One function can provide independent variable control for three dependent variable units (Integrators). The number of breakpoints per function is variable to suit the functions being fitted.



CONTROL PANEL • Binary register indicator lights, address and control lights, function switches, PB 250 transfer control switches, mode control buttons, and address and data keyboard for manual operation.

MODEL TC 5036/250 • The basic TRICE comprises a control console, patch board, PB 250 general purpose computer, and accommodates 36 computing modules. Also shown is a rack of Model M 1 analog digital converters, which may be added in any quantity depending upon the number of analog input channels.

## PACKARD BELL COMPUTER SALES OFFICES

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# TRICE

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