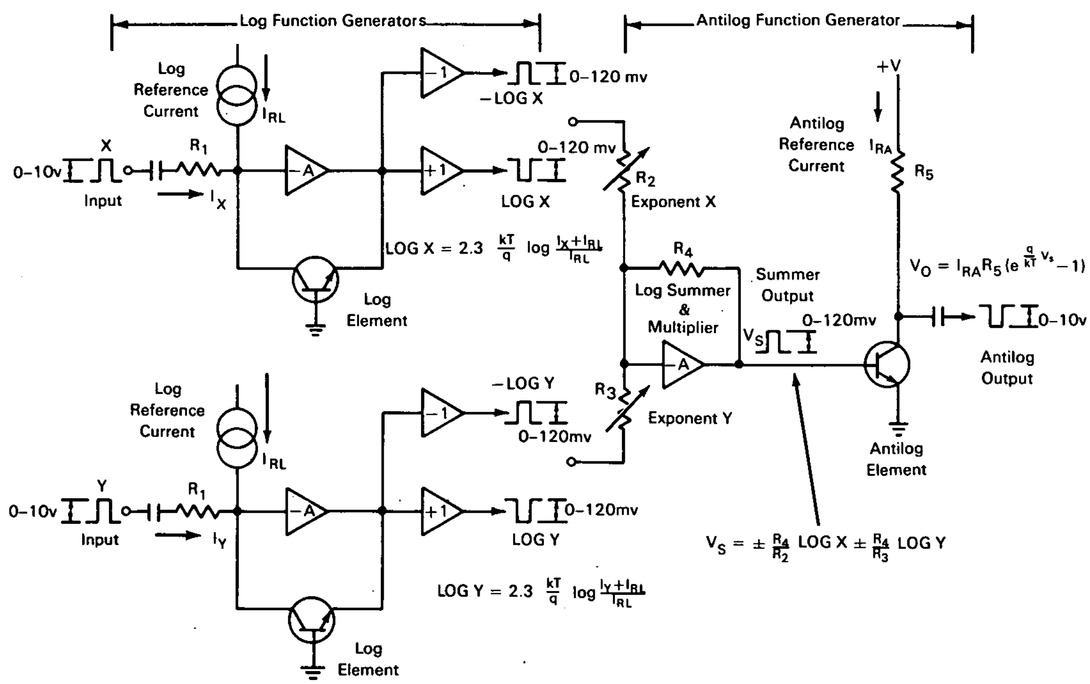
AEC-NASA TECH BRIEF

Versatile Analog Pulse Height Computer Performs Real-Time Arithmetic Operations



The problem:

To design a multipurpose pulse computer capable of performing real-time arithmetic operations on relatively fast pulses. Experimental techniques in nuclear physics often require arithmetic operations on pulses whose amplitudes convey the experimental data. These pulses may be digitized and operated on by on-line digital computers, if the computers are fast enough to handle the event rate and large enough to store all the parameters in question. Otherwise, an inexpensive analog computer can be used in conjunction with a multichannel or multiparameter analyzer. However, all analog pulse multipliers, dividers, and other similar circuits tried to date have had inadequate dynamic range, drift due to high counting rate, or slow response, and each of these circuits was designed to calculate only one specific function.

The solution:

A general purpose analog pulse height computer, capable of pulse height multiplication, division, exponentiation, addition, and subtraction. These operations are performed in about 0.5 μsec. with a precision of $\pm 0.1\%$ of full scale over a pulse height range of 20:1. The computer has been used successfully for identification of charged particles, pulse shape discrimination, measurement of mass yield distributions

(continued overleaf)

in fission, division of signals from position sensitive detectors, and generation of nonlinear energy scales in multichannel analyzers as well as for other on-line data reduction techniques.

How it's done:

Pulse height multiplication, division, and exponentiation can all be performed through the use of logarithms and antilogarithms; addition and subtraction are performed by using linear operational amplifiers. The log and antilog function generators are based on the fact that the logarithm of the collector current in a silicon planar transistor is proportional to its emitter-base voltage. Logarithmic conversion is obtained by connecting the log transistor as a feedback element in an operational amplifier. The output voltage of this amplifier is proportional to the logarithm of the input current.

The basic analog computer, shown in the figure, consists of two identical log function generators and an antilog function generator. The log function generators generate signals proportional to the logarithm of the input. These are coupled out via a noninverting and an inverting buffer to produce LOG and -LOG signals. In the antilog circuit, LOG X (or -LOG X) and LOG Y (or -LOG Y) are amplified, i.e., multiplied by a constant equal to R_4/R_2 and R_4/R_3, respectively. The resultant signals are summed in the operational amplifier and the antilog corresponding to the sum is generated. The constants R_4/R_2 and R_4/R_3 represent the exponents to which X and Y have been raised, and they can be varied between 0.4 and 2.5 by adjusting the 10-turn potentiometers R_2 and R_3. Multiplication is performed by summing two LOG signals, and division by summing a LOG and a -LOG signal.

Additional information includes a detailed discussion of the computer circuitry, performance tests, and applications.

Notes:

1. Performance tests have shown that at room temperature the computer exhibits a drift of about 0.05%/C° or ±0.03%/day. With an input rate of 10,000 counts/sec, the pulse height distribution shifts 0.2%, and with 25,000 counts/sec, it shifts 1%.
2. This information should be of interest to those concerned with the design, development, and use of instruments for nuclear pulse spectrometry and telemetry instrumentation.
3. Additional details are contained in *Review of Scientific Instruments*, vol. 36, no. 12, p. 1857–1876, December 1965.
4. Inquiries concerning this innovation may be directed to:

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   9700 South Cass Avenue
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   Reference: B67-10626

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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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