

X. ANALOG COMPUTER RESEARCH

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A. THE OPERATION OF PRESENT COMPUTERS

1. Integral Equation Solver

During the past quarter, the machine has been carefully checked for accuracy and repeatability. The results show that for well-defined problems an accuracy of one percent is realizable with excellent repeatability.

A library of Fourier transform tapes has been completed. These tapes tabulate the cosine and sine kernels on 100 points for 40 values of the parameter ω (or t). The kernels execute a maximum of 12 cycles of oscillation. A large number of Fourier transforms has been effected for laboratory personnel. In view of the value of the tape library, it is planned to add to the machine's capabilities that of duplicating its own tapes.

Particular cases of the Wiener-Hopf equation arising in network synthesis have been solved directly in the τ domain by successive approximations. The computations were based on a 20-point mid-ordinate numerical integration.

The method of gradients for computing eigenvalues and eigenvectors of linear operators has been developed in a form suitable for use on the machine.

A technical report, describing details of this machine, is in preparation.

J. M. Ham, S. Fine

B. THE USE OF COMPUTING ELEMENTS FOR NONCOMPUTATIONAL PROBLEMS

1. The Use of Computing Elements in Nonlinear Time-Domain Filters and Multiplexers

Two types of nonlinear filters have been described in the Quarterly Progress Reports, January 15, 1952 and April 15, 1952. They were based on the principle of separating two signals by virtue of their different transient waveshapes. In essence, the method is illustrated by the block diagram (Fig. X-1).

A sine-wave signal distorted by square-wave noise is present at the input to the device. The combination is differentiated and clipped at a level which removes most of the derivative of the square wave. Reintegration then yields the original sine wave with very little noise left in it.

It is now realized that the same scheme can be used for waveshape multiplexing. In the simplest case, one channel of information would be carried by frequency modulation of the sine wave, and the other by pulse-width modulation of the square wave. The sine wave is recovered as illustrated above. The square wave is recovered by

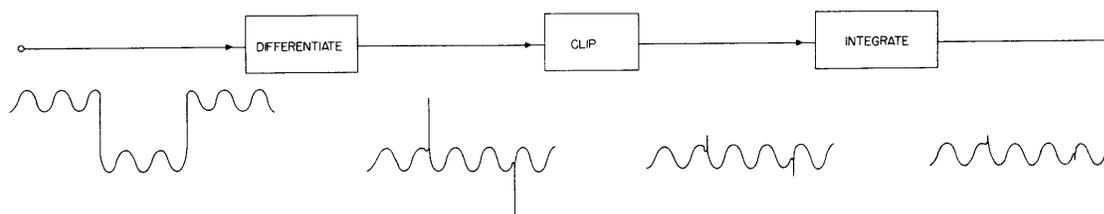


Fig. X-1

Separation of a sine and square wave.

subtracting this sine wave from the original input.

Theoretically, additional channels can be obtained by progressively more complicated waveshapes. The advantages and limitations of waveshape multiplexing are being investigated at the present time. Excellent results have been obtained for the two-channel case, using both the open-ended and the feedback schemes described in previous reports.

R. E. Scott, S. Fine

2. A Nonlinear Filter to Remove 60-Cycle Hum

Equipment is being developed to permit the separation of slowly decaying transients which occur in the presence of 60-cycle noise. A nonlinear filter which does not add a transient of its own to the desired signal is utilized.

The operation of the instrument is as follows. The desired transient signal is removed from the combined input by differentiating, clipping, and lowpass filtering. This yields the periodic noise without the superimposed transient. Synchronized with the zero crossing of the periodic noise, a sample of the transient-plus-noise input is taken. The sample is held until the following sampling instant. This results in a staircase approximation to the transient decay. The frequencies involved are such that each sample must be taken in a few microseconds and held constant for an interval that is a thousand times the sampling period. The staircase output can be displayed on an oscilloscope or recorded on an instrument such as a Brush recorder.

A full report on the instrument will be contained in a technical report that is in preparation.

K. A. Ruddock

C. THE DESIGN OF NEW COMPUTING ELEMENTS

1. A Pentode Amplifier with Direct Coupling Between Plate and Screen

An investigation was made of a direct-coupled amplifier that utilizes pentode tubes. The coupling was accomplished by connecting the plates of one stage to the screen grids of the next stage, as shown in the circuit diagram (Fig. X-2) of the three-stage

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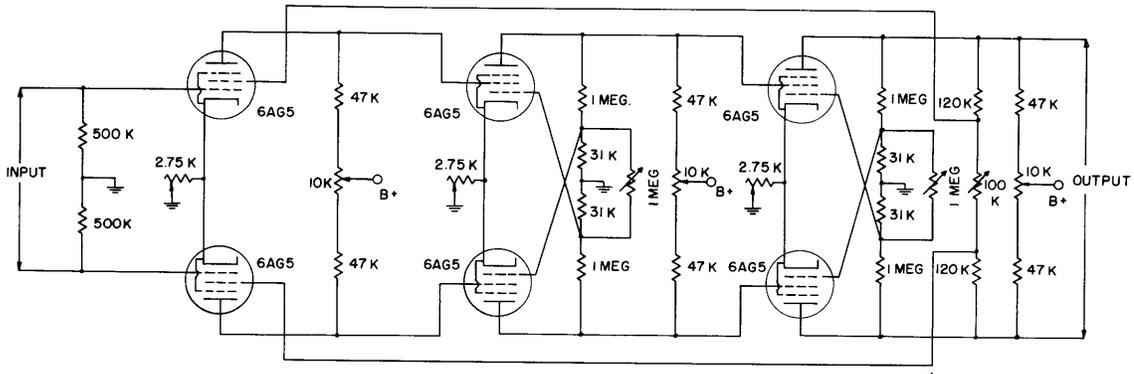


Fig. X-2

Circuit diagram of pentode amplifier with direct coupling between plate and screen.

amplifier used in this investigation.

Provision was made for positive feedback to be applied to the control grids of the second and third stages, to increase the amplification, and for negative feedback between the output and the screen grids of the first stage, to improve the linearity. The amplifier was built in balanced form in order to zero the output. Balancing is accomplished by adjustment of the 10-K potentiometers in the plate circuits. Control-grid bias adjustments are made with rheostats in the cathode circuits. Positive feedback adjustments are made with the 1-megohm controls, and the negative feedback adjustment is made with the 100-K control.

It was found that there was interaction between the positive feedback circuits in the second and third stages. With one positive feedback circuit set below a certain critical point, the other circuit operated to give positive feedback. With one positive feedback circuit set at a certain critical point, the other feedback circuit had no effect on the amplification. With one positive feedback circuit set above a certain critical point, increasing the feedback resistor of the other feedback circuit decreased the gain of the amplifier.

As much gain can be realized by adjustment of one feedback as can be realized with both. Consequently, for a multistage amplifier of this type, the positive feedback sections may well be isolated by a stage without positive feedback. Removal of negative feedback and application of positive feedback at the second stage results in linear amplification of 4000 or more. A peak-to-peak output voltage of approximately 80 volts was obtained with a supply voltage of 250 volts. Negative feedback permitted a wider range of linear operation with a resulting reduction of gain.

No drift compensation was used. Drift was found to increase when the gain of the amplifier was increased. When operated at high gain the amplifier was sensitive to vibration. Critical selection of vacuum tubes is not required in these circuits; that is,

the amplifier can be balanced upon replacing tubes. The unit has possible applications in dc analog computers.

A. W. Carlson

2. An Electronic Multiplier Using Carrier Pulse Techniques

Two variables to be multiplied are presented to the multiplier unit as direct voltages. The multiplier delivers a direct voltage as the product. The multiplying system operates as follows. The input voltages are sampled 10^4 times per second. The magnitude of each sample from one variable determines the width of a pulse whose amplitude is determined in magnitude by the corresponding sample from the second variable. The polarity of the pulse is determined by the sign of the product of the samples. The area of the pulse is evaluated by integration with an RC feedback integrator. The integrator is reset to zero in the time interval between product pulses. The output of the integrator at the end of each pulse is sampled and held until the next sample. This sampled output is the product voltage.

The range of input voltages to the multiplier is ± 50 volts. The product has the same voltage range. The basic multiplying circuitry yields an accuracy of approximately one percent of full scale product.

W. C. Jones