

[54] **DEVICE FOR INTEGRATING AND DIFFERENTIATING DISCRETE FUNCTIONS**

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[58] Field of Search. **235/183, 184, 185, 235/181, 150.51; 340/173 CA, 173 SP**

[56] **References Cited**

UNITED STATES PATENTS

3,098,997 7/1963 Means 340/173 CA
3,318,993 5/1967 Beelitz 340/173 CA

3,397,393 8/1968 Palmateer et al. 340/173 CA
3,416,143 12/1968 Goethem et al. 340/173 CA
3,445,816 5/1969 Polasek 340/173 CA
3,599,209 8/1971 Goodrich 235/181 X

OTHER PUBLICATIONS

Haskell, Design of Printed Card Capacitor Read-Only Store, IBM Journal, March 1966, p. 142-157.

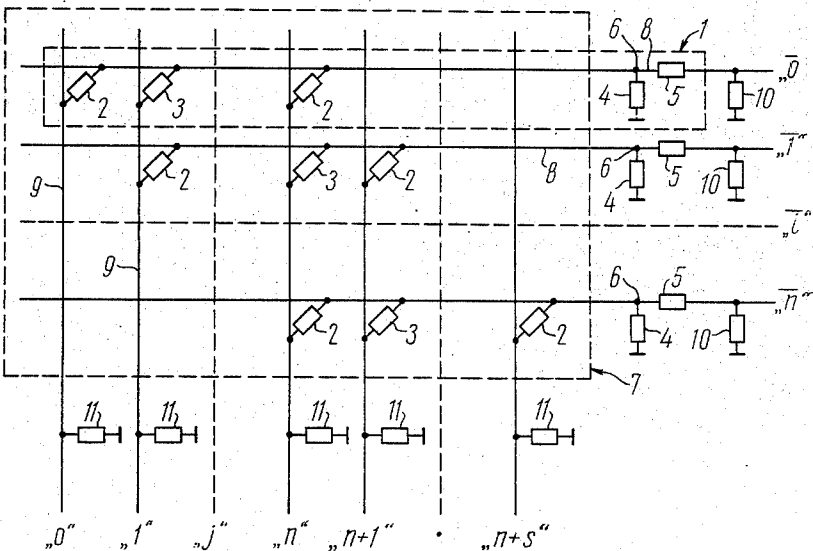
Primary Examiner—Felix D. Gruber

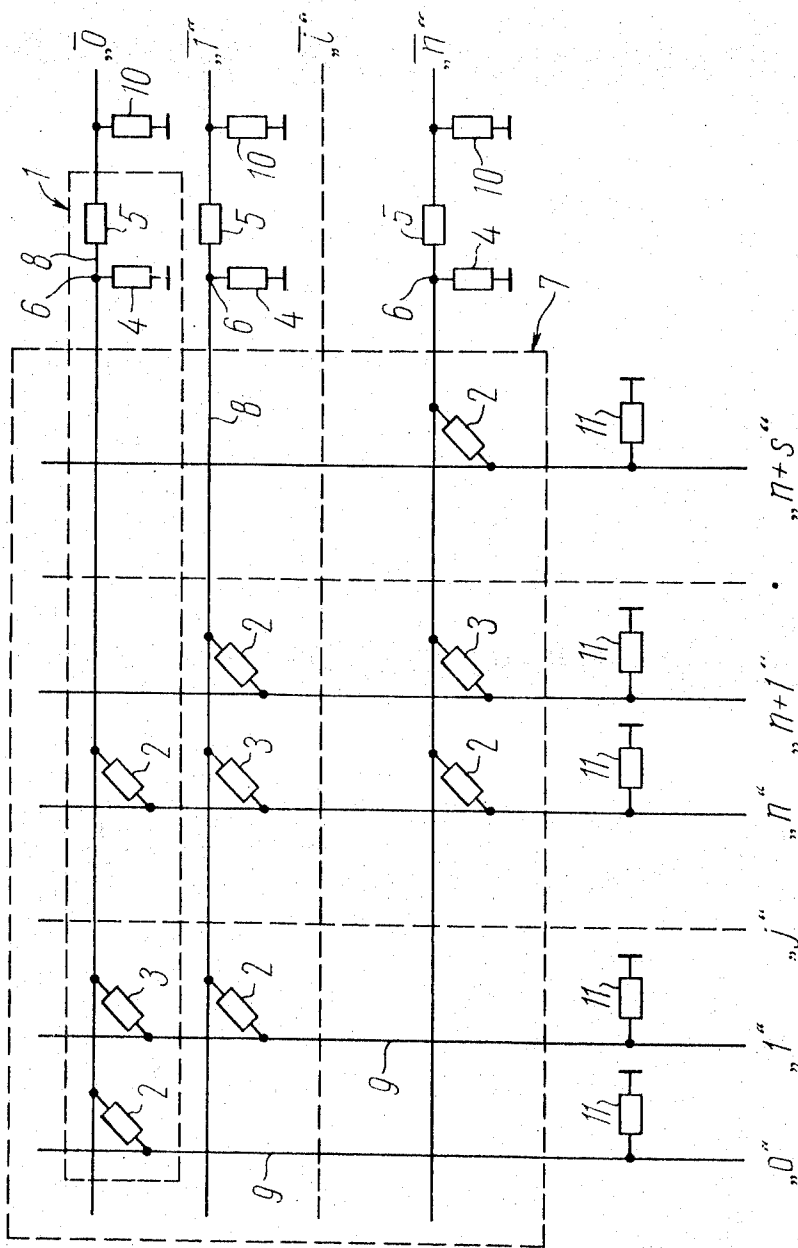
Attorney—Holman & Stern

[57] **ABSTRACT**

A device for performing one of integrating and differentiating discrete functions, arranged on the basis of reversible adders a number of which is equal to a number of points defining the discrete function, each of the reversible adders comprises at least four reactance components having a common connection point whose self admittance is zero, while each two reactance components of all said reversible adders are combined in a rectangular matrix, each third reactance component of all adders being connected to one of the rows or horizontal buses of said rectangular matrix, each fourth reactance components being connected between one of the horizontal buses of the matrix and the ground.

2 Claims, 1 Drawing Figure





DEVICE FOR INTEGRATING AND DIFFERENTIATING DISCRETE FUNCTIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to devices for integrating and differentiating discrete (matrix) functions and can find application in electronic computer engineering.

2. Description of Prior Art

Known in the art is a device for integrating and differentiating discrete functions which uses a reversible adder arranged as a direct current amplifier connected in the diagonal of a bridge circuit of admittances. The term "reversible adder" indicates a component which has an absence of unidirectivity and equivalence of external poles. A plurality of D.C. amplifiers is used in this device, and the number of D.C. amplifiers corresponds to a number of points defining the discrete function; further the admittances of all the reversible adders form two rectangular and two diagonal matrices of admittances, the rows or horizontal buses of one rectangular matrix and one diagonal matrix being connected to each other and to the inputs of the D.C. amplifiers, the horizontal buses of two other matrices being connected to each other and to the outputs of the D.C. amplifiers while the columns or vertical buses of the respective similar matrices are connected to each other.

This device, however, suffers from a number of drawbacks: it is bulky and unreliable and has a low accuracy of computations caused by a low level of operating voltages in the reversible adders arranged as D.C. amplifiers.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a device for integrating and differentiating discrete functions which uses reversible adders without D.C. amplifiers, which is energized by an alternating current of a fixed frequency and has a high reliability and accuracy of computations.

This object is achieved by providing a device for integrating and differentiating discrete functions by means of their numerical integration and differentiation, using reversible adders whose number corresponds to a number of points defining the discrete function; according to the invention, each reversible adder in the device comprises at least four reactance components having a common connection point whose self admittance is zero, two reactance components of each reversible adder being connected in a rectangular matrix, each third reactance component of each adder being connected to one of the horizontal buses of the rectangular matrix and each fourth reactance component being connected between one of the horizontal buses of the matrix and the ground.

It is advisable that to increase the accuracy of computations, an additional reactance component should be connected to each horizontal bus and to each vertical bus of the matrix, the type and the rating of the additional component being so selected as to ensure a zero self admittance of the connection point.

Among the advantages of the present device are its high reliability, compactness, light weight and small size.

The accuracy of computations obtained with this device is one order of magnitude higher than that of a similar device known in the prior art.

Two types of reactance components are known at present, they are inductances and capacitances. It is these elements that are supposed to be used in the device.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be better understood from the following description of its embodiment with reference to the appended drawing which diagrammatically illustrates a circuit diagram of a device for multiple integration and differentiation of a discrete function according to the invention.

DESCRIPTION OF PREFERRED INVENTIVE EMBODIMENT

The device for multiple (S-fold) integration and differentiation of a discrete function comprises reversible adders 1 a number "n" of which corresponds to the number of the points defining the discrete function. If it is desired therefore to provide a device which can perform the integral

$$y = \int x dt$$

then $S = 1$. Furthermore if $y = \iint x dt$ the $S = 2$ and so on. Generally y may equal $Sx dt$. S times. Each reversible adder 1 comprises $(S + 3)$ reactance components 2, 3, 4, 5 that have a common connection point 6 whose self admittance is zero. An $S + 1$ number of reactance components 2, 3 of each reversible adder 1 are combined to form a rectangular matrix 7. Each reactance component 5 is connected to one of the horizontal buses 8 (point 6) of the rectangular matrix 7, while each reactance component 4 is connected between one of the horizontal buses 8 (point 6) of the matrix 7 and the ground. Connected to each horizontal bus 8 (points "0", "1" . . . "n") and to each vertical bus 9 (points "0", "1" . . . "n + S") of the rectangular matrix 7 are additional reactance components 10 and 11, respectively. The free leads of these components are grounded, while the type of the additional reactance component in every case and its rating are selected so as to ensure a zero self-admittance of the points where they are, respectively, connected to the circuit ("0", "1", "2" . . . "n" and "0", "1", "2" . . . "n + S"). The number of rows in the rectangular matrix 7 is equal to a number of points n defining the discrete function, while the number of columns is equal to that of points n defining the discrete function plus the multiplicity S of integration or differentiation, the structure of the matrix 7 being dependent upon the multiplicity S of integration or differentiation and upon the formulas used for numerical integration and differentiation. The formula which may be used may be the rectangle formula, the trapezoidal formula, Simpsons formula or the like. Thus, for instance, a device for S-fold integration or differentiation of discrete functions, arranged in accordance with the rectangular formula (the initial point is the formula of numerical differentiation rectangles) has the structure of the rectangular matrix 7 shown in the drawing while the admittance values of every row of the matrix 7 are proportional to the number of S-element combinations of $(j-i)$, i.e. $(-1)^{j-i+1} C_{j-i}^{S-1}$ where i, j are the numbers of respective rows and col-

umns of the matrix 7 which can be $i = 0, 1, 2 \dots n$ and $j = 0, 1, 2 \dots, n + S$. The admittance ratings of the reactance components 5 are proportional to the step of the discrete function numerical integration and differentiation, while the ratings and polarities of the reactance components 4, 10, 11 which defines a value of the reactance component susceptance and type, are selected so as to ensure a zero self admittance of the points 6 of their connections "0", "1", "2" ..., "n" and "0", "1", "2" ..., "n + S." The conductivity of the capacitor may be considered positive ($j\omega c$) and the conductivity of the inductance coil negative $1/j\omega l = -j/\omega l$.

The device operates as follows.

When the (input) poles "0", "1", "2" ..., "n + S" are fed with sine voltages of a fixed frequency, and of an amplitude which corresponds to defining a discrete function $f[jt]$, where $j = 0, 1, 2 \dots n + S$, the poles "0", "1", "2" ..., "n" will produce the values of the S-th derivative of the input function computed according to the rectangle formula.

On the other hand, if sine voltages of the same frequency are applied to the poles "0", "1", "2" ..., "n", which corresponds to defining a discrete function $f[it]$, where $i = 0, 1, 2 \dots n$, and if similar voltages are applied to S poles out of $n + S$, which corresponds to defining S boundary conditions, the remaining n-poles will produce voltages whose values correspond to the S - fold integral of the input discrete function, the integral having been computed with the use of the rectangular formula and satisfying the S-boundary conditions. When use is made of another formula of numerical integration or differentiation the structure of the matrix 7 will differ from the one discussed above.

What is claimed is:

1. A device for performing one of integrating and differentiating a discrete function by numerical integration and differentiation, comprising: a plurality of re-

versible adders the number of which corresponds to a number of points of the determination interval defining the discrete function, each of said reversible adders including at least four reactance components having a common connection point whose self admittance is zero, two of said four reactance components of each said reversible adders being connected into a rectangular matrix including rows in the form of horizontal buses and columns in the form of vertical buses, the third of said four reactance components of each said reversible adder being connected to one of the horizontal buses of each said rectangular matrix, the fourth of said four reactance components of each said reversible adder being connected between one of the horizontal buses of said rectangular matrix and the ground, the device including a first set of terminal points connected to said horizontal buses and a second set of terminals connected said columns of the rectangular matrix whereby said first set and at least one of said second set of terminals corresponding to the integrating boundary conditions, is used as an input for performing integration of said discrete function, so that when a voltage representing said discrete function to be integrated is applied thereto, the integral of said function is provided at said second set of terminals, and whereby said second set is used as an input for performing differentiation so that when said representing voltage is applied thereto the differential of said function is provided at said first set of terminals.

2. A device for performing one of integrating and differentiating a discrete function as claimed in claim 1, in which additional reactance elements having free leads are connected to each horizontal bus and to each vertical bus of said rectangular matrix, the free leads of said elements being grounded, the ratings of said elements being so selected as to ensure zero self admittance at the points of their connection.

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