Feb. 4, 1969 KATSUMI TAKEMURA 3,426,186

ANALOG COMPUTING CIRCUITS FOR ABSOLUTE VALUES

Filed June 5, 1964

Fig. 1

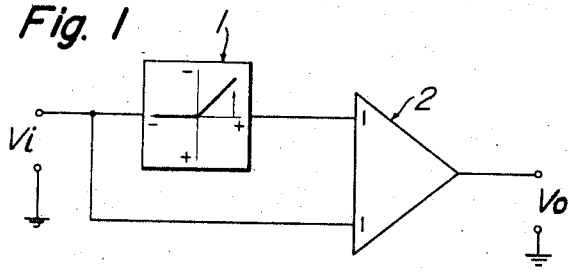


Fig. 2

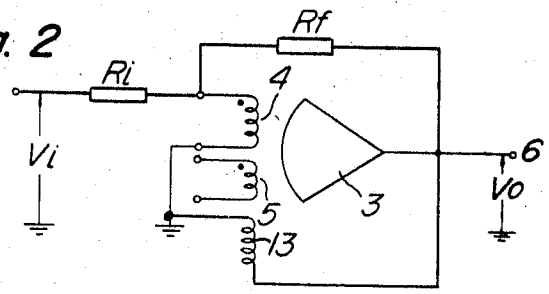


Fig. 3

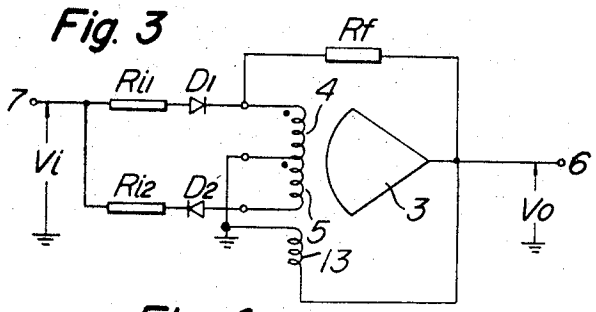
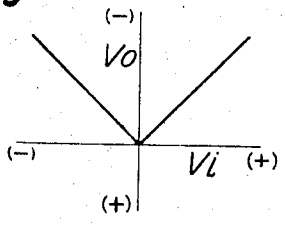


Fig. 4



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3,426,186

Patented Feb. 4, 1969

3,426,186

ANALOG COMPUTING CIRCUITS FOR ABSOLUTE VALUES

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Filed June 5, 1964, Ser. No. 372,895
Claims priority, application Japan, June 14, 1963, 38/30,534
U.S. Cl. 235—197 4 Claims
Int. Cl. G06g 7/26, 7/28; G06f 15/34

ABSTRACT OF THE DISCLOSURE

An analog computing circuit formed by a magnetic operational amplifier having two control windings operated in accordance with the ampere-turns given by two control windings, each being independently controllable. The polarity of the output signal obtained from the circuit is determined by the direction of the ampere-turns of the control windings which is unchanged regardless of the polarity of the input signals. This property is utilized to obtain an operational circuit for calculating absolute values. The input signal is supplied to each control winding through a diode in a manner to cause the control windings to generate a unidirectional ampere-turn regardless of the polarity of the input signals.

This invention relates to analog computing circuits for obtaining output signals of definite polarity proportional to the magnitudes of input signals but independent of polarities of input signals, the output signals thus representing the absolute values.

The primary object of the present invention is to provide an operational circuit of the kind specified which is simple and compact in construction and reliable in operation.

There are other objects and particularities of the present invention, which will be made obvious in the following detailed descriptions with reference to the accompanying drawings, in which;

FIG. 1 is a diagram of conventional operational circuit;

FIG. 2 is a diagram showing an operational amplifier utilized in the present invention;

FIG. 3 diagrammatically shows an embodiment of the present invention; and

FIG. 4 shows an input-output characteristic of the present invention.

Referring to FIG. 1, a conventional operational circuit for obtaining absolute values of signals is usually formed by two computing elements, that is, a function generator **1** having −2-times gain for positive input signals, for example, while zero-gain for negative input signals, and a summing amplifier **2** for providing the sums of input signals themselves and outputs of function generator **1**.

With such a construction,

$$V_o = -|V_i|$$

where V_o is the output voltage, and V_i is the input voltage. However, the need of two computing elements makes the operational circuit complex in construction, and large in size.

The present invention provides an operational circuit for obtaining absolute values of signals, simple and compact in construction by proper utilization of magnetic amplifier.

Referring now to FIG. 2, the magnetic operational amplifier **3** forming the main part of the present invention is a push-pull amplifier of self-feedback type, which includes an internal first feedback path comprised by an

impedance **13** for positive voltage feedback from the output side to have substantially infinite gain over the whole range of output. In addition, the internal first feedback path provides positive feedback of output current to compensate for load-voltage variation due to load current. The amplifier **3** has control windings **4** and **5**, which may be used independently of each other or may be used in series with each other.

In order to employ this operational amplifier as an analog computing element, the input signal is applied to the control winding **4** through an input impedance R_i, and the output signal is fed back through a second feedback path comprised by a feedback impedance R_f, as is well-known. The amplifier operates so that the ampere-turn due to current flowing through the control winding is substantially zero, and then the relation between input signal V_i and output signal V_o is

$$\frac{V_i}{V_o} = -\frac{R_f}{R_i}$$

Thus, any desirable analog computing element may be obtained.

As can be seen from the name, the above-described magnetic operational amplifier operates in accordance with ampere-turns given by two control windings which may be controlled independently of each other. The present invention utilizes such an amplifier in a proper and unique manner.

Referring to FIG. 3, the embodiment shown comprises the magnetic operational amplifier **3**, with control windings **4** and **5** connected in series. The outer ends of series-connected windings **4** and **5** are connected to an input terminal **7**, through a diode D_1 and input impedance R_{i1} in series, and a diode D_2 and input impedance R_{i2} in series, respectively. Diodes D_1 and D_2 are disposed in opposite-conduction sense to each other. The output is fed back to the outer end of winding **4** through a feedback impedance R_f. Input signal V_i is applied between input terminal **7** and the ground, while output signal V_o appears between output terminal **6** and the ground.

When V_i is positive, diode D_1 is conductive to supply ampere-turns to amplifier **3**, for providing output V_o which is opposite in polarity to the input V_i and is of magnitude determined by R_f/R_{i1}. When V_i is negative, diode D_2 conducts to supply ampere-turns to amplifier **3**. The direction of ampere-turns thus supplied is same as when V_i is positive. Thus, the output voltage V_o is same in polarity with the input, and of a magnitude determined by R_f/R_{i2}. FIG. 4 shows such an input-output characteristic.

What is claimed is:

1. Analog computing circuit for absolute value comprising a magnetic amplifier which is provided with a first feedback path for positive feedback of output voltage to assure substantially infinite gain over the whole range of the output and positive feedback of output current to compensate for variations in the load voltage due to load current, two control windings independent of each other for controlling the amplifier, an input terminal, two sets each having a series-connected diode and input impedance, each set being connected between said input terminal and one terminal of each of said control windings in such manner that the polarity of said diodes are mutually opposite and that the sense of the magnetic field produced by said control windings are in the same direction, and second feedback path means for negatively feeding back the output of said amplifier to said terminal of one of said control windings.

2. An analog computing circuit according to claim **1** wherein the second negative feedback path means has an impedance value R_f, the input impedance of that set connected to said one of said control windings having

the output of the amplifier fed back thereto has an impedance value R_{i1}, and the output signal V_o is related to the input signal V_i by the relationship $V_o/V_i=R_f/R_{i1}$.

3. An analog computing circuit according to claim 1 wherein an input signal is applied to the circuit between the input terminal and ground, an output signal is obtained from the circuit between an output terminal thereof and ground, and the remaining terminals of the two serially connected control windings are connected to ground.

4. An analog computing circuit according to claim 3 wherein the second negative feedback path means has an impedance value R_f, the input impedance of that set connected to said one of said control windings having the output of the amplifier fed back thereto has an impedance value R_{i1}, and the output signal V_o is related to the input signal V_i by the relationship $V_o/V_i=R_f/R_{i1}$.

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U.S. Cl. X.R.

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