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Triangle Wave Averaging Multiplier – A Review

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ABSTRACT

The triangle wave averaging multiplier is reformed and designed using operational amplifiers. The input voltages V_1 and V_2 are added with a reference triangle wave of peak value V_T, to get a voltage V_X. The triangle wave is added with one input voltage V_1 and subtracted with another input voltage V_2, to get a voltage V_Y. The voltage V_X is positive rectified and its average voltage V_A is obtained though a low pass filter. The voltage V_Y is negative rectified and its average voltage V_B is obtained through another low pass filter. A summing amplifier is used to get V_A-V_B-V_1. The output voltage of this summing amplifier is the output voltage V_O which is proportional to the product of the two input voltages. The peak value V_T of the triangular wave is the proportional constant and it should be stable and precession. Verification of feasibility of circuit configuration is established by way of test results on a proto type.

Introduction

There are several methods for analog multiplication. They are: (i) logarithmic function generator (ii) FET multipliers (iii) magneto resistance multiplier (iv) variable transconductance multiplier and (v) Gilberts multiplier cell, etc. The author proposed following types of analog multiplication; (i) pulse position sampled multiplication [1] (ii) double single slope multiplication [2] (iii) time division multiplication [3],[4] (iv) pulse width integrated multiplication [5] and (v) double dual slope multiplication [6].

A sawtooth wave of period T whose peak value is proportional to one input voltage is sampled by a sampling pulse whose position over the period T is proportional to another input voltage. The sampled output is proportional to the product of two input voltages. This is called pulse position sampled multiplier [1]. A short pulse train whose period T proportional to one input voltage is generated. Another input voltage is integrated during the period T. The peak value of the integrated output is proportional to the product of two input voltages. This is called double single slope multiplier [2]. If the width of a pulse train is made proportional to one voltage and the amplitude of the pulses to a second voltage, then the average value of pulse waveform is proportional to the product of two voltages, is called time division multiplier [3],[4]. A pulse train whose ON time proportional to one voltage is generated. Another input voltage is integrated during the ON time of the pulse. The peak value of the integrated output is proportional to the product of two voltages. This is called pulse width integrated multiplier [5]. The above proposed multipliers [1]-[5] are reformatted by using a sigma generator as a common basic building block for all the types and are described by the author in [7]. Square wave and triangular waveforms are generated whose time period T is proportional V_2/V_1. The third input voltage V_3 is integrated during the time period T. The peak value of the integrated output is proportional to the multiplication cum division i.e $V_O = V_2 V_3/V_1$. In this if we keep the denominator voltage as constant, the circuit will work as multiplier and is called as double dual slope multiplier [6]. The author proposed a time division multiplier without using either saw tooth wave or triangular wave as reference and is presented in [8]. A multiplier can be designed by averaging a triangle wave and called as triangle averaging multiplier. The triangular wave averaging multiplier using operational amplifiers is described in this paper.

The Proposed Analogue Multiplier

The block diagram of a triangular wave averaging multiplier is given in Fig. 1. It is made up of a triangle wave generator, summing amplifiers, diode rectifiers and low pass filters. From the block diagram shown in Fig. 1

$$V_X = V_T + V_1 + V_2 \quad (1)$$

$$V_Y = V_T + V_1 - V_2 \quad (2)$$

The voltage V_X is passed through a diode rectifier to retain positive portion of the triangular wave. The low pass filter output V_A will be

$$V_A = \frac{1}{T}\int_0^t V_M(t)dt$$

$$V_A = \frac{1}{4V_T}(V_1 + V_2 + V_T)^2 \quad (3)$$

The voltage V_Y is passes through a diode rectifier to retain negative portion of the triangular wave. The low pass filter output V_B will be

$$V_B = \frac{1}{T}\int_0^t V_N(t)dt$$

$$V_B = \frac{1}{4V_T}(-V_1 + V_2 + V_T)^2 \quad (4)$$

VA, VB and V1 are combined through a summing amplifier in such a way that

$$V_O = V_A - V_B - V_1$$

$$V_O = \frac{V_1 V_2}{V_T} \quad (5)$$

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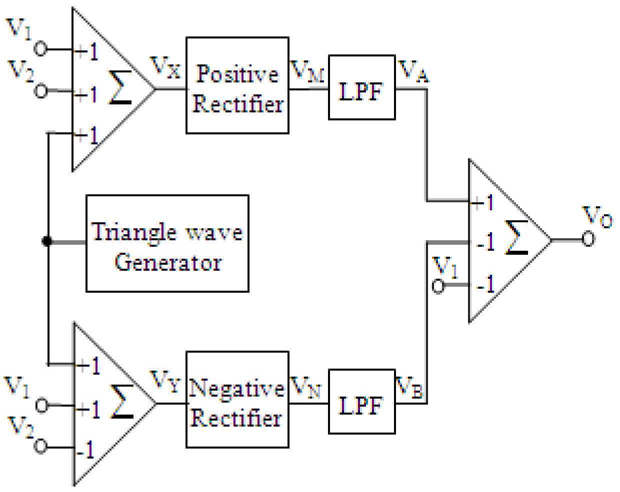

Fig 1. Block diagram of triangle averaging multiplier

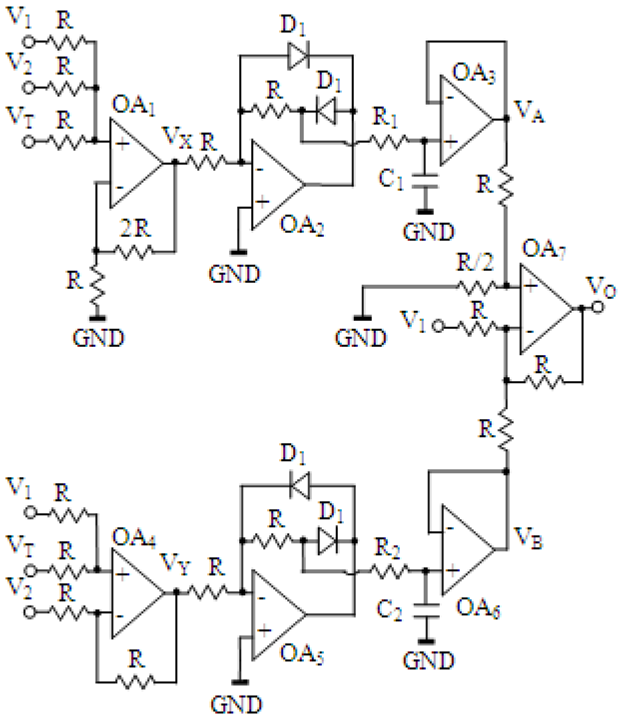

Fig 2. Circuit diagram of triangle wave averaging multiplier

Fig. 2 shows the circuit diagram of the proposed triangle averaging multiplier.

Experimental Results and Conclusions

The proposed circuit shown in Fig. 2 is tested in our laboratory. LF 356 ICs are used for all op-amps. A triangular wave of time period 40µS with peak value of 10V is used for the experiment. The test results are shown in Fig. 4. The polarity of both the input voltages V_1 and V_2 may be positive or negative. Hence proposed multiplier is four quadrant types.

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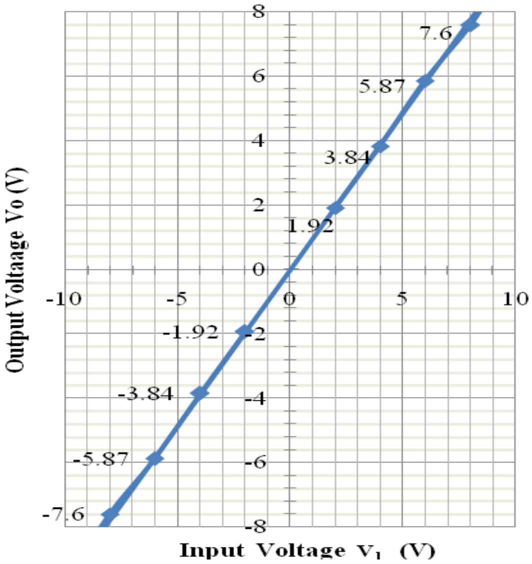

Fig 4. Test results of Fig. 2

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