March 16, 1965 JEAN-CLAUDE MARCHAIS 3,174,109

ARRANGEMENT FOR ELIMINATING DRIFT OF INTEGRATOR OUTPUT VOLTAGE

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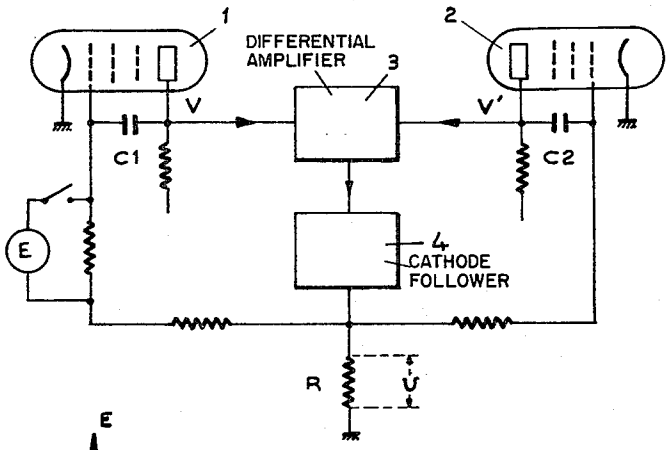


Fig. 1

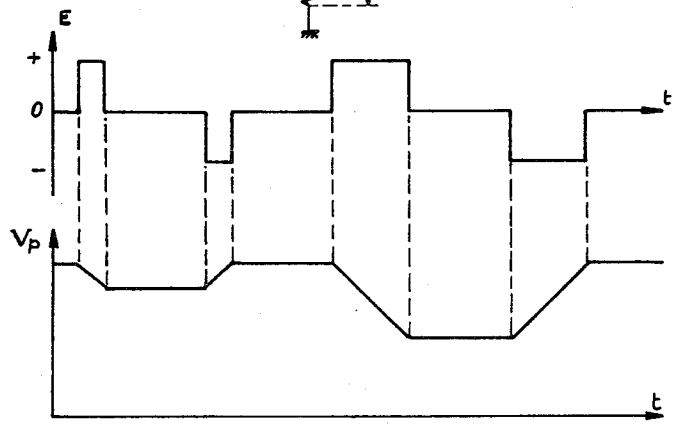


Fig. 3

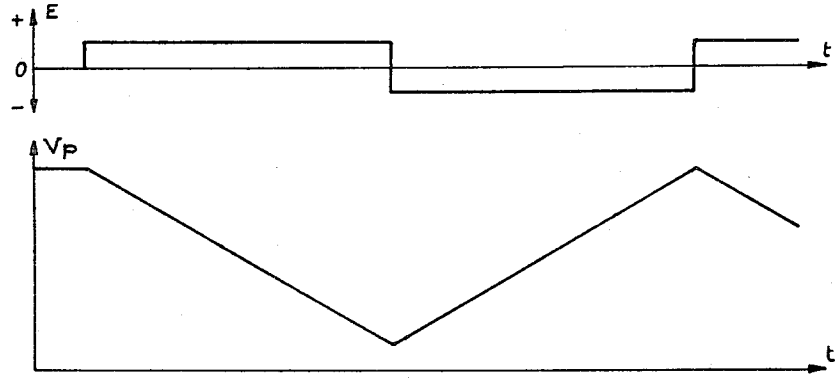


Fig. 4

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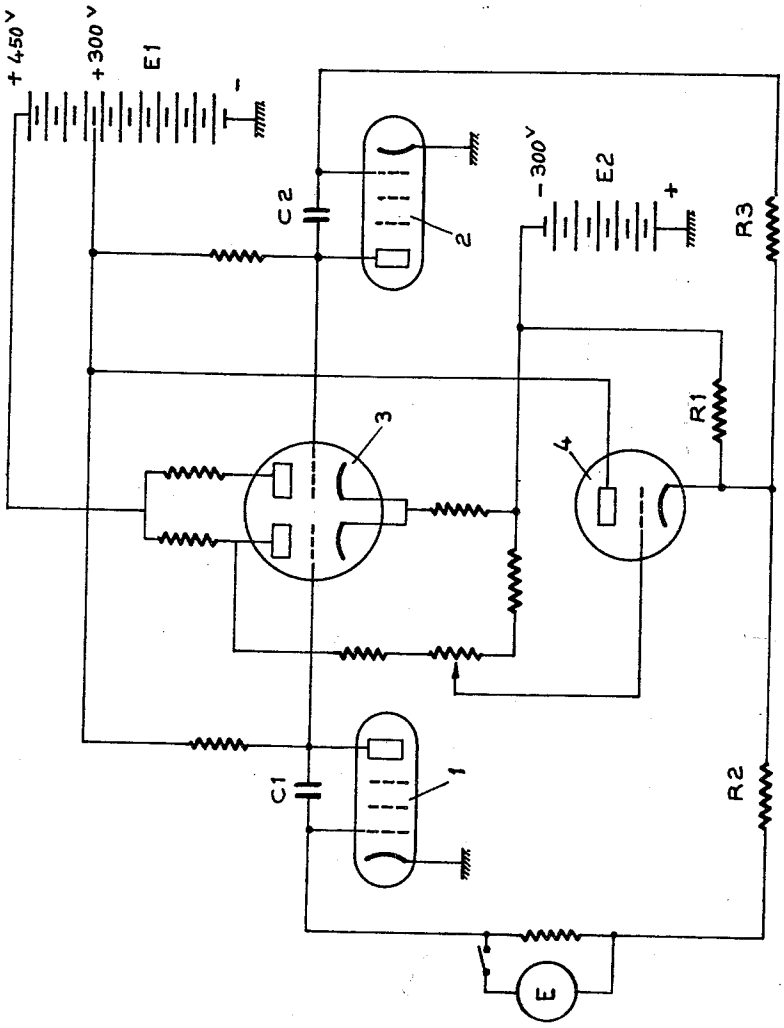
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Fig. 2



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ARRANGEMENT FOR ELIMINATING DRIFT OF INTEGRATOR OUTPUT VOLTAGE

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8 Claims. (Cl. 328—127)

The present invention relates to electronic circuits provided with integrator tubes such as those known under the name "Miller Integrator."

It is known that if a voltage E is applied to the input of the integrator tube during a time T, the voltage collected at the output passes during this time from an initial value V_0 to a value V_1 after which, with no voltage being applied any longer to the input, the output voltage drifts from the value V_1 to attain at the end of a time T_1 a value corresponding to the equilibrium of the tube, the duration of the period T_1 being a function of the characteristics of the tube and of the time constant θ of the circuits associated with the tube, which constant $\theta=RC$ is given in seconds if R is expressed in megohms and C in microfarads.

With certain applications, there exists the desire to slow down the drift in order to preserve as long as possible the output voltage V_1 obtained at the end of the period T, and for that purpose circuits are used which have a relatively long time constant.

This leads to the use of resistances and condensers of large values. However, the condensers having a very large capacity, for example, larger than 10 microfarads, are relatively bulky and present losses which are not negligible. Insofar as high resistances are concerned, employed within the grid circuits, one avoids ordinarily exceeding the value of 10 megohms by reason of the currents, either electronic or ionic, which may circulate within these circuits.

It is therefore little convenient to realize in practice circuits having a time constant very much larger than 100 seconds.

However, it is necessary with certain applications to extend the drift of an integrator over periods which are considerably longer, for example, of the order of several thousand seconds.

The difficulties noted hereinabove are also encountered with the generation, by means of electron tubes, of saw-tooth voltages of long duration.

The present invention resolves these difficulties with the aid of an electron device which reduces automatically the drift of the integrator tubes to a value which is extremely small or practically zero.

Accordingly, it is an object of the present invention to provide an integrator circuit of the type mentioned hereinabove which effectively avoids and eliminates the shortcomings and inadequacies of the prior art in a simple manner.

It is another object of the present invention to provide an integrator circuit in which the drift effect is effectively and substantially completely eliminated and which is capable of satisfactory operation even with relatively small input voltages.

Still a further object of the present invention resides in the provision of an electron integrator circuit in which the drift thereof is spread over periods of time of the order of several thousand seconds to enable versatility in its application.

Another object of the present invention resides in the provision of an integrator circuit which permits obtaining saw-tooth voltages of very long duration.

These and other objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, one embodiment in accordance with the present invention, and wherein

FIGURE 1 is a schematic diagram of an integrator arrangement in accordance with the present invention;

FIGURE 2 is a wiring diagram of one embodiment illustrating the circuits of an integrator arrangement in accordance with the present invention, and

FIGURES 3 and 4 are diagrams illustrating the wave forms obtained with the connections according to the present invention.

According to the present invention, the drift-elimination device of an integrator tube comprises a reference tube, similar to the integrator tube and connected substantially in the same manner, the control grids of the two tubes being biased by means of a common biasing voltage, a direct-current differential amplifier operative to compare the plate voltages of the two tubes in such a manner as to provide an output voltage of which the value varies inversely with respect to that of the plate voltage of the integrator tube, and means for deriving the said common biasing voltage from the said output voltage of the differential amplifier.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate corresponding parts, and more particularly to FIGURE 1, reference numeral 1 designates therein an integrator tube to the control grid of which may be applied the voltages E.

A tube 2, similar to the tube 1 and serving as reference tube, is connected in the same manner as the first tube, except that the condenser C_2 has a value much smaller than C_1, that is $C_1 \gg C_2$.

The plate voltages of the tubes 1 and 2 are applied to a direct-current differential amplifier 3 which compares these two voltages and provides at the output thereof a voltage which varies as a function of the difference of the two voltages applied to the input, the connection being such that the output voltage of the amplifier 3 increases when the plate voltage of the tube 1 decreases, and vice versa.

A transposing device 4 such as a cathode follower receives at its input the output voltage of the differential amplifier 3 and transposes the same into a voltage U at the terminals of a resistance R.

The control grids of the tubes 1 and 2 are biased with the aid of the voltage U.

Operation

The operation of the device illustrated in FIGURE 1 is as follows:

At the initial state, the tubes 1 and 2 are in equilibrium and the plate voltages V and V′ thereof have a common value V_0 determined by the value of the biasing voltage $U=U_0$ taken across the terminals of the resistance R.

If, during a period T, there is applied a direct-current voltage E to the control grid of the integrator tube 1, the plate voltage of this tube passes from the initial value $V=V_0$ to a new value $V=V_1$ which is attained at the end of the period T. After the voltage E is no longer applied to the control grid of integrator tube 1 the tube 1 would seek to return to its initial state of equilibrium if the bias voltage $U=U_0$ had remained unchanged.

However, owing to the action of the differential amplifier 3, the value of the voltage U has changed during the time T by passing from the initial value $U=U_0$ to a new value $U=U_1$. For a correct regulation of the assembly, the sense and amplitude of this change are such

that the plate voltage $V=V_1$ corresponds precisely to the grid voltage U_1 along the characteristic curve of the tube for the plate resistance utilized.

Thus, the tube **1** will preserve the plate voltage $V=V_1$ after the cessation of the input signal E and as a result thereof, there will occur only a very slight drift or practically no drift at all.

FIGURE 2 shows a detailed schematic wiring diagram of one embodiment in accordance with the present invention, it being understood that this wiring diagram is non-limitative of the present invention which may be varied at will as known to a person skilled in the art.

As in FIGURE 1, the integrator tube is designated therein by a reference numeral **1**, the reference tube by a reference numeral **2**, the differential amplifier by reference numeral **3** and the voltage transposal device by reference numeral **4**.

The differential amplifier **3** is constituted by a dual triode, it being understood, however, that two tubes of the same type which are separate from each other may also be used.

The device **4** is a triode connected as cathode follower.

A voltage source E_1 provides a positive voltage of 300 volts for the plates of the tubes **1**, **2** and **4** and a positive voltage of 450 volts for the plates of the tube **3** whereas the voltage source E_2 provides a negative voltage, with respect to ground, for the return leads of the cathodes of the tubes **3** and **4**, the cathodes of the tubes **1** and **2** being connected to ground.

The tube **1** is the integrator tube whose drift it is desired to eliminate and the tube **2** is the reference tube of which the plate voltage serves for purposes of comparison with that of the tube **1**.

The tube **2** is preferably connected as integrator like tube **1** but with a condenser C_2 much smaller than the condenser C_1 (in one embodiment realized by applicant, the condenser C_1 had a value of 10 microfarads and the condenser C_2 a value of 0.1 microfarad).

However, it is also within the purview of the present invention not to connect the tube **2** as integrator provided there is realized in another manner an equivalent time constant, necessary to the stability of the circuit.

Voltages E are applied to the cotrol grid of tube **1**, and the bias for the grids of tubes **1** and **2** is taken from the junction of the resistance R_1 with the cathode of the tube **4**.

It may be readily seen that when the plate voltage of the tube **1** decreases, as a result of the application of a positive voltage E to the control grid of this tube, the output voltage of the differential amplifier **3**, taken at the left plate thereof, increases, and as a result thereof there will appear a positive increase of the voltage at the terminals of the resistance R_1. The voltages applied to the control grid of the integrator tube are therefore subjected to variations which maintain the plate voltage of the tube after the cessation of the signal E in such a manner that the drift is substantially reduced to zero.

A substantial elimination of the drift has numerous applications. Inter alia, it permits utilization of circuits with time constants that are relatively little significant for the realization of saw-tooth voltage generators of very long period. This possibility is due to the fact that the arrangements without drift may operate with input voltages of very low value, of the order of a fraction of a volt, whereas the usual arrangements, in which the drift is not reduced substantially to zero, necessitate generally the application of input voltages of the order of 10 to 30 volts.

Thus, with the connection shown in FIGURE 2 in which $R_2=R_3=10$ megohms and $C_1=10$ microfarads, consequently a time constant for the tube equal to 100 seconds, it has been possible to obtain at the plate of the tube **1** a saw-tooth voltage of a period of several hours by applying to the input of the tube a rectangular voltage of very small value, for example, of 0.1 volt. Under these conditions, the plate voltage of the tube **1** varies linearly by 200 volts, passing during the period indicated from 50 to 250 volts.

FIGURES 3 and 4 illustrate the variations of the plate voltage V_p of the integrator tube as a function of the voltages E of diverse forms, applied to the control grid of the integrator tube in a circuit according to the present invention. In particular, FIGURE 4 shows a symmetric saw tooth obtained with the aid of a direct current input voltage having positive and negative pulses.

While I have shown and described one embodiment in accordance with the present invention, it is understood that the same is not limited thereto, but is susceptible of many changes and modifications within the spirit and scope thereof all of which lead to a substantial elimination of the drift in a circuit having a time constant for the utilization of the principle mentioned hereinabove and illustrated in FIGURE 1.

Thus, it is clear that the present invention may be modified in numerous ways by a person skilled in the art and I therefore do not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. A drift-eliminating arrangement, comprising an integrator tube, a reference tube substantially identical to said integrator tube, each of said two tubes having a grid and a plate, and each of said two tubes developing plate potentials susceptible to vary during operation thereof, means including a differential direct current amplifier for comparing the plate potentials of said two tubes in such a manner as to provide an output voltage that increases when the plate potential of said integrator tube decreases and vice versa, means for deriving from said output voltage a bias voltage, and means for applying said bias voltage to the grids of said two tubes, thereby to substantially eliminate drift from said integrator tube.

2. A drift-eliminating arrangement, comprising an integrator tube, a reference tube substantially identical to said integrator tube, each of said two tubes having a grid and a plate, and each of said two tubes developing plate potentials susceptible to vary during operation thereof, means including a differential direct current amplifier for comparing the plate potentials of said two tubes in such a manner as to provide an output voltage that increases when the plate potential of said integrator tube decreases and vice versa, means for deriving from said output voltage a bias voltage, means for applying said bias voltage to the grids of said two tubes, thereby to substantially eliminate drift from said integrator tube, and means for applying to the grid of said integrator tube alternately positive and negative voltages within periods of equal duration to thereby produce on the plate of said integrator tube saw-tooth voltages having ascending and descending periods of equal duration.

3. A drift-eliminating arrangement comprising an integrator tube, a reference tube, each of said two tubes developing potentials susceptible to vary during operation thereof, comparing means for comparing the potentials developed by said two tubes to provide an output voltage, means for producing a bias voltage derived from said output voltage, and means for applying said bias voltage to said two tubes to thereby substantially eliminate drift from said integrator tube.

4. An anti drift arrangement, comprising integrator means, reference means, each of said integrator and reference means effectively providing a potential, means for comparing the potentials of said integrator means and of said reference means to produce a control voltage, and control means operatively connecting said comparing means with said integrator means to apply said control voltage to said integrator means to thereby maintain the potential of said integrator means and therewith substantially eliminate drift from said integrator means.

5. A saw-tooth generator, comprising integrator means, reference means, each of said integrator and reference means effectively providing a potential, means operatively connected to said two first-mentioned means for comparing the potentials produced therein to provide a control voltage, and means for applying control signals to said integrator means to produce therein saw-tooth voltages.

6. An integrator arrangement including an integrator tube and a reference tube, said two tubes being substantially identical and wired in substantially the same manner, each of said tubes having a grid and a plate, and each of said two tubes developing plate potentials susceptible to vary during operation thereof, a source of a common bias voltage for biasing the grids of both said tubes, and means for deriving said bias voltage from the difference V'–V of the reference tube plate potential V' and the integrator tube plate potential V.

7. An arrangement as in claim 6, wherein said deriving means include a differential direct current amplifier having an input and an output and operable to compare said plate potentials V and V', and a cathode follower also having an input and an output, the output of said differential amplifier being connected to the input of said cathode follower, while said bias voltage is taken at the output of said cathode follower.

8. An arrangement as in claim 7, including a condenser C_1 connected between the plate and the gird of said integrator tube, and a condenser C_2, connected between the plate and the grid of the reference tube, the capacity of C_1 being much greater than the capacity of C_2.

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