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(54) MULTIVIBRATOR CIRCUIT

- (71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
- 10 The invention relates to a multivibrator circuit having a variable oscillation frequency and including a first and a second transistor which each have a control electrode, a supply electrode and an output electrode, the supply electrodes of the two transistors being inter-coupled via a capacitive element, whilst the control electrode of at least one of the transistors is coupled to the output electrode of the other transistor, a first output current from a current source circuit being supplied to the junction point of the supply electrode of the first transistor and the capacitive element and a second output current from this current source circuit being supplied to the junction point of the supply electrode of the second transistor and the capacitive element, the magnitudes of these currents being dependent upon a control signal applied to this current source circuit.
- 20 If the transistors used are bipolar transistors the invention relates to what is generally termed an emitter-coupled multivibrator. The oscillation frequency of such a multivibrator is determined by the time required to charge the capacitive element to a first threshold value and by the time required to discharge this capacitive element to a second threshold value. Thus this oscillation frequency is determined by the value of the capacitive element, the values of the charging and discharging currents and the voltage swing of the capacitive element, i.e. the voltage difference between the said two threshold values. To enable the oscillation frequency to be varied one these quantities can be made variable.
- is described, for example, in United States Patent Specification No. 3,061,799. In the multivibrator circuits described in this Specification the oscillation frequency is varied by means of variable charging and discharging currents which may simultaneously be controlled. However, in this known multivibrator circuit, in order to obtain a variable oscillation frequency further provisions are necessary to ensure that the voltage swing of the capacitive element is maintained constant irrespective of the values of the charging and discharging currents, for without these additional provisions this voltage swing would vary in proportion to these currents, so that a current variation would have no effect at all on the oscillation frequency.
- Further more additional provisions are necessary in this known multivibrator circuit to obtain a frequently desired constant pulse height of the square-wave output signal. For this purpose the output signal is limited by means of a limiter circuit, causing the pulse height to be determined by the parameters of this limiter circuit irrespective of the frequency.
- As a result of the necessity of the said additional provisions the possible frequency swing, i.e. the difference between the maximum and minimum frequencies of oscillation, is limited. Furthermore, in this known multivibrator circuit the current source circuit has to satisfy exacting requirements, especially if a constant pulse duty factor, i.e. a constant ratio between the effective pulse duration and the spacing of the output signal is desired.
- It is an object of the present invention to provide a multivibrator circuit of the type described at the beginning of this specification in which the said additional provisions may be dispensed with, so that the restrictions and disadvantages due to these additional provisions are avoided, and which also has a highly satisfactory stability and sensitivity without the various elements of the circuit having to satisfy extremely high requirements in respect of accuracy.

[Price 25p]

Price 75p

The invention is characterized in that the current-source circuit includes a differential stage having a sum terminal, two control terminals and two output terminals, whilst to the sum terminal a constant current is supplied which is divided between the two output terminals in accordance with the control signal for the current source circuit which is applied as a differential signal to the control terminals of the differential stage, and in that it further includes a four-quadrant multiplier circuit having two input current terminals which are connected to the output terminals of the differential stage, two output terminals which supply the output currents of the current source circuit, and two input control terminals to at least one of which a switching signal is applied which depends upon the state of the multivibrator, so that the output currents of the current source circuit alternately are equal to the respective currents at the input current terminals of the multiplier circuit.

The provisions according to the invention first ensure that both the voltage swing of the capacitive element and the pulse height of the output signal are constant, i.e. independent of the frequency of oscillation, without special provisions, such as a limiter circuit, being required. Further it is ensured that the pulse duty factor of the output signal automatically is equal to 1/2, irrespective of the frequency of oscillation and without the current source circuit having to satisfy special requirements. Furthermore the circuit has the advantage that the control signal may be applied to the current source circuit as a differential signal, which provides large advantages in respect of supply voltage influence and drift problems.

If the multivibrator circuit according to the invention is made entirely symmetrical by coupling the control electrodes of the first and the second transistor to the output electrode of the respective other transistor and by supplying mutually inverse switching signals to the two input control terminals of the multiplier circuit, a circuit is obtained the operation of which is largely independent of the supply voltage and hence of any variations of this supply voltage.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which

Figure 1 is a schematic circuit diagram of the multivibrator circuit described in the aforementioned United States Patent Specification, and

Figures 2 and 3 are schematic circuit diagrams of two embodiments of the multivibrator circuit according to the invention.

The multivibrator circuit shown in Figure 1 in which bipolar transistors of the NPN type are used, first comprises an oscillator

part including transistors T_1 and T_2 the emitters of which are interconnected via a capacitor C and the collector leads of which include resistors R_1 and R_2 respectively, the base of the transistor T_2 being coupled to the collector of the transistor T_1 . The base of the transistor T_1 is at a fixed reference voltage in the form of the Zener voltage of a Zener diode Z_3 . The Zener diode Z_3 forms part of a series combination of three Zener diodes Z_1 , Z_2 and Z_3 and a resistor R_7 , which series combination at one end is connected to a positive terminal $+V_B$ of a voltage supply source and at the other end is connected to earth potential.

The terminals of the capacitor C each are connected to an output of a current source circuit, which two outputs are constituted by the collector electrodes of two transistors T_3 and T_4 . The emitter electrodes of these transistors are interconnected via two resistors R_3 and R_4 . The junction point of these resistors is connected via a resistor R_5 to earth and also, via a resistor R_6 , to a negative terminal $-V_B$ of the voltage supply source. The transistors T_3 and T_4 thus act as current sources, the magnitudes of the currents supplied by them depending upon the voltage applied to their bases. This base voltage is determined by a control signal V_i which is applied to the base of a transistor T_5 the emitter of which is connected to the bases of the transistors T_3 and T_4 and the collector of which is connected to a point of fixed potential, in this case to the cathode of the Zener diode Z_3 .

The operation of the multivibrator circuit is based on the alternate conduction of one of the transistors T_1 and T_2 , the time during which each of these transistors is conducting being determined by the value of the capacitor C , the magnitude of the current flowing through this capacitor and the magnitude of the voltage swing, i.e. the voltage difference between the threshold values to which the capacitor is charged and discharged. Assuming, for example, the transistor T_1 to be conducting, then its collector voltage and hence the base voltage of the transistor T_2 is comparatively low. Owing to the voltage which in this state of the multivibrator is set up across the charged capacitor C , the base emitter junction of the transistor T_2 will be biased in the reverse direction, so that this transistor is cut off. As a result, a current will flow through the capacitor C which is equal to the collector current of the transistor T_1 and which discharges this capacitor. When the capacitor is discharged to an extent such that the emitter voltage of the transistor T_2 falls below the base voltage of this transistor, this transistor T_2 will become conducting and the transistor T_1 will become non-conducting. Consequently the capacitor C is charged by a current equal to the collector

current of the transistor T_3 , until the emitter voltage of the transistor T_1 has fallen below the base voltage of this transistor, which causes this transistor T_1 to become conducting again and the transistor T_2 to become non-conducting, so that the next cycle commences. Since the transistors T_1 and T_2 are alternately conducting, the voltage V_o across one of the collector resistors, for example the resistor R_2 , will be a square-wave voltage.

If the current source circuit is designed so that the collector currents of the transistors T_3 and T_4 are equal, by using identical transistors T_3 and T_4 and equal resistors R_3 and R_4 , the pulse duty factor of the output signal will be $1/2$, since in this case the charging current of the capacitor C is equal to the discharging current and hence the times during which the transistors T_1 and T_2 are conducting also are equal. By varying the base voltage of the transistors T_3 and T_4 the charging and discharging currents of the capacitor can be varied and hence in principle the frequency of oscillation may be varied, the pulse duty factor remaining constant, because the charging and discharging currents of the capacitor C always vary equally.

If, however, no additional provisions are made, no frequency control is possible in this manner, for a change in the currents supplied by the current source circuit would cause a proportional change in the voltage swing across the capacitor C , because a variation of these currents involves a variation of the current flowing through the transistor T_1 during the time in which this transistor is conducting. The voltage drop produced across the resistor R_1 by this current, however, determines one of the threshold values and hence the voltage swing across the capacitor, since this voltage determines the base voltage of the transistor T_2 . Because the voltage swing across the capacitor C thus is determined by the magnitudes of the current supplied by the current source circuit, variation of these currents does not provide a frequency variation, unless further provisions are made.

These further provisions comprise the said Zener diodes Z_1 , Z_2 , Z_3 , connected in series with the resistor R_7 . The collector of the transistor T_1 is connected via the anode cathode path of a diode D_1 to the cathode of the Zener diode Z_1 and via the cathode anode path of a diode D_2 to the anode of this Zener diode. This ensures that the minimum collector voltage of the transistor T_1 and hence the minimum base voltage of the transistor T_2 is equal to twice the Zener voltage, namely the sum of the Zener voltages of the Zener diodes Z_2 and Z_3 . The maximum base voltage is thrice the Zener voltage, so that the voltage swing at the base of the transistor T_2 is equal to one Zener voltage. The voltage

swing across the capacitor C now is equal to this voltage swing at the base of the transistor T_2 , because the base of the transistor T_1 has a fixed potential, so that this voltage swing across the capacitor also is one Zener voltage. Consequently this voltage swing is dependent upon the currents supplied by the current source circuit, so that variation of these currents actually enables the frequency of oscillation to be varied.

If in this circuit the output signal V_o is taken from the collector of the transistor T_2 , the pulse height of this square-wave output signal depends upon the frequency, because the magnitude of the current flowing through the resistor R_2 is proportional to the frequency set. If the pulse height is to be maintained constant, this requires, for example, an additional limiter.

This additional limiter is not required if the output signal is taken from the collector of the transistor T_1 , because this collector voltage is already limited by means of the Zener diodes, for the maximum collector voltage is thrice the Zener voltage and the minimum collector voltage is twice the Zener voltage, so that the pulse height of this output signal will be one Zener voltage.

Obviously, an essential disadvantage of the known circuit is the need for the additional provisions, including the three Zener diodes. Furthermore these additional provisions impose limitations on the circuit. To ensure that the voltage swing across the capacitor is constant the sum of the two currents supplied by the current source circuit must at least exceed a given minimum value, i.e. a value such that the voltage drop produced across the resistor R_1 by this current is such that the limiter is rendered operative via the diode D_2 . This means, however, that the frequency of oscillation has a given minimum limiting value. The sum of the currents and hence the frequency of oscillation also have a maximum value, i.e. the value at which via the path R_7 , Z_1 , D_2 an amount of current such is to be supplied to the collector of the transistor T_1 that no current is supplied to the Zener diodes Z_2 and Z_3 .

If furthermore a constant and hence frequency-independent pulse duty factor is to be obtained, particular attention must be paid to the design of the current source circuit. If, for example, the pulse duty factor is to be an $1/2$, the characteristics of the transistors T_3 and T_4 must be identical with a high degree of accuracy and the resistors R_3 and R_4 also must be exactly equal.

Figure 2 shows a first embodiment of a multivibrator circuit according to the invention. The circuit first includes an oscillator part which comprises transistors T_{11} and T_{12} , the emitters of which are interconnected via a capacitor C , and collector resistors R_{11} and R_{12} . The base of the transistor T_{12} is con-

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connected to the collector of the transistor T_{11} via an emitter follower T_{19} , whilst the base of the transistor T_{11} is connected to a reference voltage V_R . The emitter follower T_{19} reduces the load imposed on the resistor R_{11} , but it is not essential for the operation of the circuit and may if desired be dispensed with.

The current source circuit includes a first differential stage comprising transistors T_{13} and T_{14} the emitters of which are connected to a current source S_{11} . The current source circuit further includes a second differential stage which comprises transistors T_{15} and T_{16} the emitters of which are connected to the collector of the transistor T_{13} , and a third differential stage comprising transistors T_{17} and T_{18} the emitters of which are connected to the collector of the transistor T_{14} . These second and third differential stages together form a configuration which corresponds to that of a four-quadrant multiplier in that the bases of the transistors T_{13} and T_{18} are interconnected, as are the bases of the transistors T_{16} and T_{17} , the collectors of the transistors T_{15} and T_{17} and the collectors of the transistors T_{16} and T_{18} . In this configuration the collectors of the transistors T_{13} and T_{17} form a first output of the current source circuit and are connected to the emitter of the transistor T_{11} , whilst the collectors of the transistors T_{16} and T_{18} form the second output of this current source circuit and are connected to the emitter of the transistor T_{12} . Furthermore the bases of the transistors T_{13} and T_{18} receive a switching signal which via a level-shifting circuit comprising diodes D_{11} and D_{12} is derived from the base of the transistor T_{12} . The bases of the transistors T_{16} and T_{17} are connected to a reference voltage V_R' . The current required for the diodes D_{11} and D_{12} and the transistor T_{19} is supplied by a current source S_{12} .

In the operation of the multivibrator circuit the transistors T_{11} and T_{12} will again alternately be conducting. With a suitable choice of the reference voltage V_R' the transistors T_{16} , T_{17} and T_{13} , T_{18} also will alternately conduct, because the bases of the transistors T_{15} and T_{18} are coupled to the base of the transistor T_{12} . This has far-reaching consequences for the operation of the multivibrator circuit, as will now be set out.

Assuming, for example, that at a certain instant the transistor T_{11} is conducting and the transistor T_{12} is non-conducting. The base voltage of the transistor T_{12} then is comparatively low and hence so are the base voltages of the transistors T_{15} and T_{18} . As a result, at a suitable value of the reference voltage V_R' these transistors T_{15} and T_{18} will be non-conducting, whilst the transistors T_{16} and T_{17} are conducting. This means that the collector current of the transistor T_{13} , say I , is supplied via the transistor T_{16} to the

capacitor C , whilst the collector current of the transistor T_{14} , say $I_0 - I$, where I_0 is equal to the current supplied by the current source S_{11} , is supplied to the transistor T_{11} via the transistor T_{17} . Thus the current through the capacitor C is equal to the collector current I of the transistor T_{13} , whilst the overall current through the transistor T_{11} is equal to I_0 , i.e. the sum of the collector currents of the transistors T_{13} and T_{14} .

When the capacitor C is discharged by the current I to a voltage such that the transistor T_{12} becomes conducting and the transistor T_{11} becomes non-conducting, the transistors T_{16} and T_{17} also become non-conducting and the transistors T_{15} and T_{18} become conducting. The charging current for the capacitor C then is again supplied by the collector of the transistor T_{13} , but now via the transistor T_{15} , whilst the collector current of the transistor T_{14} is supplied via the transistor T_{17} to the transistor T_{12} .

This shows that both the charging current and the discharging current of the capacitor are supplied by the collector of the transistor T_{13} and hence each are equal to I . It is further shown that the frequency of oscillation can be varied by variations of this current I due to the application of a differential signal V_f to the bases of the transistors T_{13} and T_{14} without the need for additional provisions, for a change of the differential voltage V_f changes the collector current I of the transistor T_{13} and hence the charging and discharging currents of the capacitor. In contradistinction to the known circuit, however, the voltage swing of the capacitor automatically is constant, because the sum of the currents supplied by the current supply circuit always is constant, i.e. equal to I_0 , and this voltage swing is determined by the sum of these currents.

Thus, the first advantage of the circuit according to the invention as compared with the known circuit is that no further provisions are required for maintaining constant the voltage swing of the capacitor. Consequently, in the multivibrator according to the invention the restriction with respect to the frequency swing also does not occur. The maximum frequency is twice the rest frequency ($f = I_0/2$) and is limited only by the cut-off frequency of the transistors, whilst the minimum frequency is limited only by the leakage currents and the amplification factor of the transistors.

Furthermore the pulse height of the output signals across the two resistors R_{11} and R_{12} is independent of the frequency, because this pulse height is determined by the constant current I_0 through these resistors. The pulse duty factor of the output signal automatically is equal to an $1/2$, because the charging current and the discharging current of the capacitor automatically are equal to one

another, since they are both supplied by the transistor T_{13} .

5 A final advantage is that the control signal V_i can be supplied as a differential signal, so that supply voltage variations exert less influence and drift phenomena are considerably reduced.

10 Figure 3 shows a second embodiment. The oscillator part again includes two transistors T_{21} and T_{22} the emitters of which are coupled via a capacitor C and which have collector resistors R_{21} and R_{22} respectively. In this embodiment, however, the base of each of the transistors T_{21} and T_{22} is coupled to the collector of the respective other transistor via transistors T_{23} and T_{30} respectively which are connected as emitter followers. The current source circuit is substantially equal to that of Figure 2 and comprises transistors T_{23} to T_{25} , a difference consisting in that the bases of the transistors T_{26} and T_{27} are not connected to a reference voltage but via a level shifting circuit D_{24} , D_{25} , D_{26} receive a switching signal from the base of the transistor T_{21} . Furthermore the outputs of this current source circuit are connected to the terminals of the capacitor C not directly, but via the emitter collector paths of transistors T_{31} and T_{32} . The bases of these transistors T_{31} and T_{32} are connected to a fixed reference voltage which is derived from the supply voltage $+V_B$ by means of diodes D_{27} , D_{28} and D_{29} . The quiescent current required for the emitter follower T_{29} and for the level shifting circuit D_{24} to D_{26} is supplied by a current source S_{22} , the current required for the emitter follower T_{30} and the level shifting circuit D_{21} to D_{23} by a current source S_{23} , and the current required for the level shifting circuit D_{27} to D_{29} by a current source S_{24} .

40 The operation of this completely symmetrical circuit otherwise is entirely identical to that of the circuit shown in Figure 2. The use of the emitter followers T_{29} and T_{30} ensures that only very small loads are imposed on the collector resistors. The transistors T_{31} and T_{32} produce an additional separation between the oscillator part and the current source circuit.

50 In comparison to the embodiment shown in Figure 2 the embodiment shown in Figure 3 has the advantage that the dependence upon the supply voltage is reduced. In the embodiment shown in Figure 2 the voltage swing of the capacitor still depends upon the supply voltage, because the reference voltage V_R at the base of the transistor T_{11} in general will be dependent upon this supply voltage. In the embodiment shown in Figure 3 the frequency of oscillation is entirely independent of the supply voltage and is determined only by the value of the capacitor C , the values of the resistors R_{21} and R_{22} and the control signal V_i .

65 The temperature dependence of the circuit

may largely be compensated by using current sources S_{22} to S_{24} having positive temperature coefficients. Further it will be apparent that the circuits described may be modified according to the field of application without departing from the spirit and the scope of the invention. In some uses a separate drive of the difference stage T_{23} , T_{24} will be required to obtain a satisfactory linear relationship between the frequency and the control signal. For this purpose, for example, the control signal may in known manner be supplied as a difference current to two diodes connected in the forward direction or to transistors connected as diodes which on the one hand are connected to a point of fixed potential and on the other hand to the bases of the transistors T_{23} and T_{24} .

70 If, for example, when the circuit is used in a phase-locked loop, much importance is attached to high sensitivity, the control signal may obviously be directly applied as a differential voltage to the bases of the transistors T_{23} and T_{24} . Also, the differential stage T_{23} , T_{24} and the current source S_{21} may be replaced by two intercoupled current inverter circuits as described, for example, in "International Solid State Circuits Conference", 1971, page 185, Figure 3. In such a configuration a common-mode current supplied to the input is amplified by a factor which depends upon the geometry of the transistors used, for example unity, whilst a differential current supplied to the input is amplified by a factor equal to the current amplification factor of the transistors, which consequently may be considerable.

80 Further it will be appreciated that the level shifting circuits may be designed differently, for example may comprise Zener diodes. Also, the output signal V_o may be taken from other points, for example from the emitter of one of the emitter followers T_{29} and T_{30} . When the voltage across the capacitor C is used as the output voltage the circuit arrangement may act as a triangular voltage generator.

85 Finally, although in the embodiments shown the multivibrator circuit includes bipolar transistors, it may obviously, in some cases even advantageously, include unipolar transistors, such as field effect transistors, the gates of which may or may not be isolated.

WHAT WE CLAIM IS:—

1. Multivibrator having a variable frequency of oscillation and including a first and a second transistor which each have a control electrode, a supply electrode and an output electrode, the supply electrodes of the two transistors being intercoupled via a capacitive element, whilst the control electrode of at least one of the transistors is coupled to the output electrode of the other transistor, a first output current of a current



another, since they are both supplied by the transistor T_{12} .

5 A final advantage is that the control signal V_i can be supplied as a differential signal, so that supply voltage variations exert less influence and drift phenomena are considerably reduced.

Figure 3 shows a second embodiment. The oscillator part again includes two transistors T_{21} and T_{22} the emitters of which are coupled via a capacitor C and which have collector resistors R_{21} and R_{22} respectively. In this embodiment, however, the base of each of the transistors T_{21} and T_{22} is coupled to the collector of the respective other transistor via transistors T_{29} and T_{30} respectively which are connected as emitter followers. The current source circuit is substantially equal to that of Figure 2 and comprises transistors T_{23} to T_{27} , a difference consisting in that the bases of the transistors T_{26} and T_{27} are not connected to a reference voltage but via a level shifting circuit D_{24} , D_{25} , D_{26} receive a switching signal from the base of the transistor T_{21} . Furthermore the outputs of this current source circuit are connected to the terminals of the capacitor C not directly, but via the emitter collector paths of transistors T_{31} and T_{32} . The bases of these transistors T_{31} and T_{32} are connected to a fixed reference voltage which is derived from the supply voltage $+V_R$ by means of diodes D_{27} , D_{28} and D_{29} . The quiescent current required for the emitter follower T_{29} and for the level shifting circuit D_{24} to D_{26} is supplied by a current source S_{22} , the current required for the emitter follower T_{30} and the level shifting circuit D_{21} to D_{23} by a current source S_{23} , and the current required for the level shifting circuit D_{27} to D_{29} by a current source S_{24} .

The operation of this completely symmetrical circuit otherwise is entirely identical to that of the circuit shown in Figure 2. The use of the emitter followers T_{29} and T_{30} ensures that only very small loads are imposed on the collector resistors. The transistors T_{31} and T_{32} produce an additional separation between the oscillator part and the current source circuit.

50 In comparison to the embodiment shown in Figure 2 the embodiment shown in Figure 3 has the advantage that the dependence upon the supply voltage is reduced. In the embodiment shown in Figure 2 the voltage swing of the capacitor still depends upon the supply voltage, because the reference voltage V_R at the base of the transistor T_{11} in general will be dependent upon this supply voltage. In the embodiment shown in Figure 3 the frequency of oscillation is entirely independent of the supply voltage and is determined only by the value of the capacitor C, the values of the resistors R_{21} and R_{22} and the control signal V_i .

65 The temperature dependence of the circuit

may largely be compensated by using current sources S_{22} to S_{24} having positive temperature coefficients. Further it will be apparent that the circuits described may be modified according to the field of application without departing from the spirit and the scope of the invention. In some uses a separate drive of the difference stage T_{23} , T_{24} will be required to obtain a satisfactory linear relationship between the frequency and the control signal. For this purpose, for example, the control signal may in known manner be supplied as a difference current to two diodes connected in the forward direction or to transistors connected as diodes which on the one hand are connected to a point of fixed potential and on the other hand to the bases of the transistors T_{23} and T_{24} .

If, for example, when the circuit is used in a phase-locked loop, much importance is attached to high sensitivity, the control signal may obviously be directly applied as a differential voltage to the bases of the transistors T_{23} and T_{24} . Also, the differential stage T_{23} , T_{24} and the current source S_{21} may be replaced by two intercoupled current inverter circuits as described, for example, in "International Solid State Circuits Conference", 1971, page 185, Figure 3. In such a configuration a common-mode current supplied to the input is amplified by a factor which depends upon the geometry of the transistors used, for example unity, whilst a differential current supplied to the input is amplified by a factor equal to the current amplification factor of the transistors, which consequently may be considerable.

Further it will be appreciated that the level shifting circuits may be designed differently, for example may comprise Zener diodes. Also, the output signal V_o may be taken from other points, for example from the emitter of one of the emitter followers T_{29} and T_{30} . When the voltage across the capacitor C is used as the output voltage the circuit arrangement may act as a triangular voltage generator.

Finally, although in the embodiments shown the multivibrator circuit includes bipolar transistors, it may obviously, in some cases even advantageously, include unipolar transistors, such as field effect transistors, the gates of which may or may not be isolated.

WHAT WE CLAIM IS:—

1. Multivibrator having a variable frequency of oscillation and including a first and a second transistor which each have a control electrode, a supply electrode and an output electrode, the supply electrodes of the two transistors being intercoupled via a capacitive element, whilst the control electrode of at least one of the transistors is coupled to the output electrode of the other transistor, a first output current of a current

source circuit being supplied to the junction point of the supply electrodes of the first transistor and the capacitive element and a second output current of this current source circuit being supplied to the junction point of the supply electrode of the second transistor and the capacitive element, the magnitudes of these currents depending upon a control signal applied to the said current source circuit, characterized in that the current source circuit includes a differential stage having a sum terminal, two control terminals and two output terminals, whilst to the sum terminal a constant current is supplied which is divided between the two output terminals in accordance with the control signal for the current source circuit which is applied as a differential signal to the control terminals of the differential stage, and in that the current source circuit further includes a four-quadrant multiplier circuit having two input current terminals which are connected to the output terminals of the differential stage, two output terminals which supply the output currents of the current source circuit, and two input control terminals to at least one of which a switching signal depending upon the state of the multivibrator is applied

so that the output currents of the current source circuit alternately are equal to the respective currents at the input current terminals of the multiplier circuit. 30

2. Multivibrator circuit as claimed in claim 1, characterized in that a switching signal which depends upon the position of the multivibrator circuit is applied to each of the two input control terminals of the multiplier circuit, the switching signals being inverse with respect to one another. 35

3. Multivibrator circuit as claimed in claim 1 or claim 2, characterized in that the differential stage comprises a differentially connected transistor pair to the control electrodes of which the control signal is applied. 40

4. Multivibrator circuit substantially as hereinbefore described with reference to Figure 2 or Figure 3 of the accompanying drawings. 45

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