

Description

The invention relates to an oscillator circuit comprising first and second transistors whose emitters are intercoupled and jointly connected to the collector of a third transistor, the first transistor being connected in a grounded base connection delivering a circuit voltage across a parallel resonant circuit coupled to the collector of the first transistor, the collector being coupled to the base of the second transistor for a regenerative feedback of the circuit voltage.

Such an oscillator circuit is described in US-A-3,649,929.

When the prior art oscillator circuits are produced in larger quantities, the individual circuits may mutually show spread in the amplitude of the oscillator output signal, for example due to inaccuracies in the values of the circuit elements. In addition, the oscillator amplitude may vary due to *inter alia* temperature fluctuations or ageing.

In order to keep the oscillator amplitude i.e. the amplitude of said circuit voltage at a constant value the known oscillator circuit comprises an AGC-circuit for reducing the gain of the transistors when the oscillator amplitude increases and vice versa. In said AGC-circuit the amplitude of the circuit voltage is detected and converted into a DC-gain control signal, which is applied to the base of the third transistor. However, for a proper amplitude detection the known oscillator circuit needs a comparatively large capacitance and is therefore not so suitable for integration. In addition the amplitude detection when used in an oscillator circuit introduces a certain degree of control inertia, which may result in unwanted transients.

The invention has for its object to provide an oscillator circuit comprising a simple stabilizing circuit, which can be easily integrated and stabilizes the oscillator amplitude at a predetermined value without any noticeable delay and highly independent of the spread in values of the resonant circuit elements.

According to the invention, an oscillator circuit of the type described in the opening paragraph is characterized in that the collector of the first transistor is AC-coupled to the base of the third transistor for a negative feedback of the circuit voltage.

The invention is based on the recognition that a negative feedback of the circuit voltage, when properly dimensioned, does not deteriorate the regenerative feedback required for oscillation and provides the possibility to stabilize the oscillator amplitude without amplitude detection.

By applying the measure according to the invention an increase or decrease respectively of the collector current of the third transistor instantaneous coincides with a decrease or increase, respectively in the conduction of the first transistor. If the oscillator amplitude increases, for example as a result of the abovementioned ambient factors, then also the collector current of the third transistor increases, which for a suitably

chosen transistor setting results in an instantaneous decrease of the collector current of the first transistor applied to the resonant circuit. The reverse holds for the case in which the oscillator amplitude decreases.

Although the collector current of the second transistor varies in the same phase as the oscillator signal this does not have any effect on the circuit voltage as the second transistor only functions as an emitter follower and its collector current flows to ground without passing through the resonant circuit.

A preferred embodiment of the oscillator circuit according to the invention is characterized by a fourth transistor, whose base is connected to a fixed base biasing voltage and whose emitter is coupled to the emitter of the third transistor, both emitters being jointly connected to a constant current source, the current thereof at the biasing voltages of the third and fourth transistors flowing to a sufficient extent through the third transistor for amplifying the circuit voltage in the first transistor, such that regeneration the circuit voltage taking place.

When this measure is applied, the emitter currents of the first and second transistors vary more than linear with the circuit voltage, which is fed back to the base of the third transistor, as a result of which the influence of the resonant circuit quality on the amplitude of the circuit voltage decreases still further.

Another preferred embodiment of the oscillator circuit according to the invention is characterized in that the collector of the first transistor is coupled *v/a* an emitter follower to a first voltage divider a first output of which is AC-connected to the base of the second transistor and a second output to the base of the third transistor and in that a second voltage divider is arranged between a supply voltage and ground a first output thereof being coupled to the base of the first transistor and a second output to the base of the fourth transistor.

When this measure is applied an adequate setting of on the one hand a sufficiently strong positive feedback to maintain an oscillation and on the other hand a sufficiently strong negative feedback for an acceptable stabilization of the oscillator amplitude can be obtained in a simple way.

The invention will now be described in greater detail by way of example with reference to the Figures in the accompanying drawing

Therein:

Figure 1 shows an oscillator circuit according to the invention;

Figures 2A-2D show the voltage and time-dependent variations, respectively of the current of the variable current source used in the oscillator circuit of Figure 1 and the voltage and time-dependent variations of the current applied to the resonant circuit.

Figures 3A-3C show the voltage and time-dependent variations, respectively of the current of a different embodiment of the variable current

source and that of the current applied to the resonant circuit.

Figure 1 shows an oscillator circuit according to the invention comprising first and second emitter-coupled transistors T_1 and T_2 , respectively with a variable current source T_3 , T_4 , R included in a common emitter path. The current source T_3 , T_4 , R comprises third and fourth emitter-coupled transistors T_3 and T_4 , respectively with a high ohmic resistor R included in a common emitter path and acting as a constant current source. The collector of the third transistor T_3 is connected to the coupled emitters of the first and second transistors T_1 and T_2 . The base of this third transistor T_3 constitutes a control input of the variable current source T_3 , T_4 , R .

The base biasing of said transistor T_1 — T_4 are obtained by d.c. coupling from a supply voltage $1/2 V_B$ via emitter followers T_5 and T_6 and first and second voltage dividers D_1 , D_2 , R_1 — R_3 and D_3 , D_4 , R_4 — R_6 . In this situation the collectors of the two emitter followers T_5 and T_6 are connected to a supply voltages V_B . This first voltage divider D_1 , D_2 , R_1 — R_3 comprises, arranged between the emitter output of the emitter follower T_5 and ground, a series arrangement of, in succession, a diode D_1 , three resistors R_1 — R_3 and a diode D_2 , which has a first output D_1 located at the junction between the resistors R_1 and R_2 and connected to the base of the second transistor T_2 and a second output O_2 located at the junction between the transistors R_2 and R_3 and connected to the base of the third transistor T_3 . The second voltage divider D_3 , D_4 , R_4 — R_6 comprises, arranged between the emitter output of the emitter follower T_6 and ground, a series arrangement of, in succession, a diode D_3 , a resistor R_4 , a diode D_4 and two resistors R_5 and R_6 , which has a first output O_3 located at the junction between the resistor R_4 and the diode D_4 and connected to the base of the first transistor T_1 and a second output O_4 at the junction between the resistors R_5 and R_6 and connected to the base of the fourth transistor T_4 .

The resistors R_1 and R_4 ; R_2 and R_5 ; R_3 and R_6 have mutually identical values, as have also the diodes D_1 — D_4 , so that the base biasing voltages of the first and second transistors T_1 and T_2 are mutually the same, whilst the base biasing voltage of the third transistor T_3 is located one diode voltage step higher than the base biasing voltage of the fourth transistor T_4 . As a result thereof, in the rest position, the third transistor T_3 is in a conducting state and the fourth transistor T_4 is non-conductive, whilst the first and second transistors T_1 and T_2 are mutually in balance. The collectors of the second and fourth transistors T_2 and T_4 are connected to the supply voltage V_B and therewith connected to earth for RF, so that these transistors are arranged in a grounded-collector connection. The base of the emitter follower T_5 is connected to the supply voltage $1/2 V_B$ and therewith connected to earth for RF, so that the first transistor T_1 is arranged to a grounded-base connection. The collector of the first transistor T_1 is connected via a parallel LC-resonant circuit to the

supply voltage $1/2 V_B$ and constitutes an output V_{osc} of the oscillator circuit. This collector is connected to the base of the emitter follower T_6 , as a result of which the voltage across the resonant circuit LC or so called circuit voltage is positively feedback to the base of the second transistor T_2 via this emitter follower T_6 and the first voltage divider D_1 , D_2 , R_1 — R_3 . The second transistor T_2 forms together with the first transistor T_1 a switching differential amplifier T_1 , T_2 whose output voltage at the collector of T_1 is in phase with the input voltage at the base of T_2 . This output voltage is at its maximum at the resonant frequency of the LC-resonant circuit, so that in a manner which is known *per se* at an adequate gain of the differential amplifier T_1 , T_2 , that is to say at a sufficiently large collector current of T_3 a loop gain equal to unity for said resonant frequency is reached and a spontaneous oscillator is effected from a rest or initial condition.

The amplitude of the circuit voltage, i.e. the oscillator amplitude depends on the quality factor of the LC-resonant circuit and the magnitude of the collector current of T_1 applied to this circuit. An instantaneous stabilization of the circuit voltage is obtained by modulating said collector current in anti-phase by the circuit voltage, that is to say by reducing the collector current instantaneously at an increasing circuit voltage and *vice versa*. By increasing the circuit voltage-dependent collector current variation the stabilization can be improved.

In the embodiment shown such a modulation of the collector current of T_1 is obtained because that portion of the circuit voltage being applied to the base of T_3 is in-phase with the circuit voltage portion applied to the base of T_2 . As, in addition, the transistors T_1 and T_2 switch alternately and in mutual phase opposition from the conductive to the non-conductive state, the collector current of the first transistor T_1 , when conducting, corresponds to the collector current of the third transistor T_3 .

The third transistor T_3 forms, together with the fourth transistor T_4 a differential amplifier T_3 , T_4 , which in certain circumstances acts as a current limiter and whose output current varies in a highly non-linear way with the input voltage. The base biasing voltage of T_3 is one diode voltage step higher than the base biasing voltage of T_4 , as a result of which on the one hand, as mentioned above, a spontaneous oscillation from the rest or initial condition is possible and on the other hand the range in which the collector current of T_3 has its maximum variation versus the base voltage and in which circuit voltage amplitude deviations are negatively feedback to the highest degree, has been set advantageously for the chosen use of the oscillator circuit.

Then the collector current of the third transistor T_3 varies in dependence on the base input voltage as illustrated in Figure 2A by means of curve 1. Starting from a certain standardized value Q for the quality factor of the LC-resonant circuit, a sinusoidal circuit voltage having a given desired

amplitude whose variation is illustrated in Figure 2B by means of curve 2, was obtained. The variation of the collector current of the third transistor T_3 and the variation of the first transistor T_1 are illustrated by means of the respective curves Q in Figures 2C and 2D, respectively. A reduction of the circuit voltage, for example due to a variation of the tuning of the LC-resonant circuit because of the use of an LC-resonant circuit having a lower quality factor Q_L or due to ambient factors result in variations of the collector currents of T_3 and T_1 as illustrated by the respective curves Q_L in Figure 2B and Figure 2C, respectively, in response thereto and average collector current of T_1 increases instantaneously, so that the circuit voltage also increases instantaneously to the desired standardized value. The opposite situation is obtained when the circuit voltage is increased; the collector currents of T_3 and T_1 , respectively varies as illustrated by curves Q_L in Figures 2B and 2C, respectively. Then the average collector current from T_1 to the circuit decreases instantaneously, so that also the circuit voltage decreases instantaneously to the desired standardized value. In said practical embodiment the resistors had the following values:

R_1 and R_4 : 200 Ω

R_2 and R_5 : 700 Ω

R_3 , R_6 and R : 1 K Ω .

The LC-resonant circuit was tunable between 10 and 17 MHz and had a quality factor varying between 30 and 50. Also larger variations of the quality factor, for example between 10 and 130 had hardly any noticeable influence on the oscillator amplitude, thanks to the stabilizing action of the oscillator circuit according to the invention.

It will be obvious that the invention is not limited to the embodiment shown. Thus, it is alternatively possible to omit the fourth transistor T_4 and to use only the third transistor T_3 with the resistor R as the variable current source for the differential amplifier T_1 , T_2 . The collector current of the third transistor T_3 then varies linearly versus the base voltage, as illustrated in Figure 3A by means of curve 3. Starting from a circuit voltage varying as shown in Figure 2B by means of curve 2, the collector current of T_3 and T_1 , respectively varies as shown in the respective Figures 3B and 3C for the desired standardized value of the circuit voltage amplitude in accordance with curve Q for a certain increase in the circuit voltage amplitude in accordance with the curve Q_L and for a certain decrease in accordance with the curve Q_L .

It should be noted that for a person skilled in the art it will not be difficult to apply the inventive idea to circuits of different types, which in essence function in the same way as the circuit shown and by using, for example, a non-switching differential amplifier T_1 , T_2 . It will further be obvious that the word "transistor" also includes field effect transistors, of which, as is known, the gate, source and drain electrodes, respectively correspond to the base, collector and emitter

electrodes of bipolar transistors, used in this description.

Claims

1. An oscillator circuit comprising first and second transistors (T_1 , T_2) whose emitters are intercoupled and jointly connected to the collector of a third transistor (T_3), the first transistor (T_1) being connected in a grounded base connection delivering a circuit voltage across a parallel resonant circuit (LC) coupled to the collector of the first transistor (T_1), the collector being coupled to the base of the second transistor (T_2) for a regenerative feedback of the circuit voltage, characterized in that the collector of the first transistor (T_1) is AC-coupled to the base of the third transistor (T_3) for a negative feedback of the circuit voltage.

2. An oscillator circuit as claimed in Claim 1, characterized by a fourth transistor (T_4), whose base is connected to a fixed base biasing voltage and whose emitter is coupled to the emitter of the third transistor (T_3), both emitters being jointly connected to a constant current source, the current thereof at the biasing voltages of the third and fourth transistors (T_3 , T_4) flowing to a sufficient extent through the third transistor (T_3) for amplifying the circuit voltage in the first transistor (T_1), such that regeneration of the circuit voltage taking place.

3. An oscillator circuit as claimed in Claim 2, characterized in that the collector of the first transistor is coupled via an emitter follower (T_5) to a first voltage divider (D_1 , D_2 , R_1 — R_3) a first output (O_1) of which is AC-connected to the base of the second transistor (T_2) and a second output (O_2) to the base of the third transistor (T_3) and in that a second voltage divider (D_3 , D_4 , R_4 — R_6) is arranged between a supply voltage ($\frac{1}{2} V_B$) and ground, a first output (O_3) thereof being coupled to the base of the first transistor (T_1) and a second output (O_4) to the base of the fourth transistor (T_4).

Patentansprüche

1. Oszillatorschaltung mit ersten und zweiten Transistoren (T_1 , T_2), deren Emittierelektroden miteinander sowie mit dem Kollektor eines dritten Transistors (T_3) verbunden sind, wobei der erste Transistor (T_1) in basisgeerdeter Schaltung geschaltet ist, die an einem mit dem Kollektor des ersten Transistors (T_1) gekoppelten Parallel-Resonanzkreis (LC) eine Kreisspannung liefert, wobei dieser Kollektor zur regenerativen Rückkopplung der Kreisspannung mit der Basis des zweiten Transistors (T_2) gekoppelt ist, dadurch gekennzeichnet, dass der Kollektor des ersten Transistors (T_1) zur negativen Rückkopplung der Kreisspannung wechselstrommässig mit der Basis des dritten Transistors (T_3) gekoppelt ist.

2. Oszillatorschaltung nach Anspruch 1, gekennzeichnet durch einen vierten Transistor (T_4), dessen Basis mit einer festen Basiseinstellung versehen ist und dessen Emittier mit

amplitude whose variation is illustrated in Figure 2B by means of curve 2, was obtained. The variation of the collector current of the third transistor T_3 and the variation of the first transistor T_1 are illustrated by means of the respective curves Q in Figures 2C and 2D, respectively. A reduction of the circuit voltage, for example due to a variation of the tuning of the LC-resonant circuit because of the use of an LC-resonant circuit having a lower quality factor Q_L or due to ambient factors result in variations of the collector currents of T_3 and T_1 as illustrated by the respective curves Q_L in Figure 2B and Figure 2C, respectively, in response thereto and average collector current of T_1 increases instantaneously, so that the circuit voltage also increases instantaneously to the desired standardized value. The opposite situation is obtained when the circuit voltage is increased; the collector currents of T_3 and T_1 , respectively varies as illustrated by curves Q_L in Figures 2B and 2C, respectively. Then the average collector current from T_1 to the circuit decreases instantaneously, so that also the circuit voltage decreases instantaneously to the desired standardized value. In said practical embodiment the resistors had the following values:

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It will be obvious that the invention is not limited to the embodiment shown. Thus, it is alternatively possible to omit the fourth transistor T_4 and to use only the third transistor T_3 with the resistor R as the variable current source for the differential amplifier T_1 , T_2 . The collector current of the third transistor T_3 then varies linearly versus the base voltage, as illustrated in Figure 3A by means of curve 3. Starting from a circuit voltage varying as shown in Figure 2B by means of curve 2, the collector current of T_3 and T_1 , respectively varies as shown in the respective Figures 3B and 3C for the desired standardized value of the circuit voltage amplitude in accordance with curve Q for a certain increase in the circuit voltage amplitude in accordance with the curve Q_L and for a certain decrease in accordance with the curve Q_L .

It should be noted that for a person skilled in the art it will not be difficult to apply the inventive idea to circuits of different types, which in essence function in the same way as the circuit shown and by using, for example, a non-switching differential amplifier T_1 , T_2 . It will further be obvious that the word "transistor" also includes field effect transistors, of which, as is known, the gate, source and drain electrodes, respectively correspond to the base, collector and emitter

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1. An oscillator circuit comprising first and second transistors (T_1 , T_2) whose emitters are intercoupled and jointly connected to the collector of a third transistor (T_3), the first transistor (T_1) being connected in a grounded base connection delivering a circuit voltage across a parallel resonant circuit (LC) coupled to the collector of the first transistor (T_1), the collector being coupled to the base of the second transistor (T_2) for a regenerative feedback of the circuit voltage, characterized in that the collector of the first transistor (T_1) is AC-coupled to the base of the third transistor (T_3) for a negative feedback of the circuit voltage.

2. An oscillator circuit as claimed in Claim 1, characterized by a fourth transistor (T_4), whose base is connected to a fixed base biasing voltage and whose emitter is coupled to the emitter of the third transistor (T_3), both emitters being jointly connected to a constant current source, the current thereof at the biasing voltages of the third and fourth transistors (T_3 , T_4) flowing to a sufficient extent through the third transistor (T_3) for amplifying the circuit voltage in the first transistor (T_1), such that regeneration of the circuit voltage taking place.

3. An oscillator circuit as claimed in Claim 2, characterized in that the collector of the first transistor is coupled via an emitter follower (T_5) to a first voltage divider (D_1 , D_2 , R_1 — R_3) a first output (O_1) of which is AC-connected to the base of the second transistor (T_2) and a second output (O_2) to the base of the third transistor (T_3) and in that a second voltage divider (D_3 , D_4 , R_4 — R_6) is arranged between a supply voltage ($\frac{1}{2} V_B$) and ground, a first output (O_3) thereof being coupled to the base of the first transistor (T_1) and a second output (O_4) to the base of the fourth transistor (T_4).

Patentansprüche

1. Oszillatorschaltung mit ersten und zweiten Transistoren (T_1 , T_2), deren Emittierelektroden miteinander sowie mit dem Kollektor eines dritten Transistors (T_3) verbunden sind, wobei der erste Transistor (T_1) in basisgeerdeter Schaltung geschaltet ist, die an einem mit dem Kollektor des ersten Transistors (T_1) gekoppelten Parallel-Resonanzkreis (LC) eine Kreisspannung liefert, wobei dieser Kollektor zur regenerativen Rückkopplung der Kreisspannung mit der Basis des zweiten Transistors (T_2) gekoppelt ist, dadurch gekennzeichnet, dass der Kollektor des ersten Transistors (T_1) zur negativen Rückkopplung der Kreisspannung wechselstrommässig mit der Basis des dritten Transistors (T_3) gekoppelt ist.

2. Oszillatorschaltung nach Anspruch 1, gekennzeichnet durch einen vierten Transistor (T_4), dessen Basis mit einer festen Basiseinstellung versehen ist und dessen Emmitter mit



dem Emitter des dritten Transistors (T_3) verbunden ist, wobei die beiden Emittierelektroden gemeinsam mit einer Quelle konstanten Stromes verbunden sind, wobei dieser Strom bei der Einstellspannung des dritten und vierten Transistors (T_3, T_4) in ausreichenden Masse durch den dritten Transistor (T_3) fließt um die Kreisspannung in dem ersten Transistor (T_1) derart zu verstärken, dass Regeneration der Kreisspannung auftritt.

3. Oszillatorschaltung nach Anspruch 2, dadurch gekennzeichnet, dass der Kollektor des ersten Transistors über einen Emitterfolger (T_5) mit einem ersten Spannungsteiler (D_1, D_2, R_1-R_3) gekoppelt ist, von dem ein erster Ausgang (O_1) wechselstrommässig mit der Basis des zweiten Transistors (T_2) verbunden ist und von dem ein zweiter Ausgang (O_2) mit der Basis des dritten Transistors (T_3) verbunden ist und dass ein zweiter Spannungsteiler (D_3, D_4, R_5-R_6) zwischen einer Speisespannung ($1/2 V_B$) und Erde vorgesehen ist, wobei ein erster Ausgang (O_3) mit der Basis des ersten Transistors (T_1) und ein zweiter Ausgang (O_4) mit der Basis des vierten Transistors (T_4) verbunden ist.

Revendications

1. Circuit oscillateur comprenant un premier et un deuxième transistor (T_1, T_2), dont les émetteurs sont couplés l'un à l'autre et connecté conjointement au collecteur d'un troisième transistor (T_3), le premier transistor (T_1) étant connecté dans un montage à base commune fournissant une tension de circuit à un circuit résonnant

parallèle (LC) couplé au collecteur du premier transistor (T_1), le collecteur étant couplé à la base du deuxième transistor (T_2) en vue d'une rétroaction positive de la tension de circuit, caractérisé en ce que le collecteur du premier transistor (T_1) est couplé en courant alternatif à la base du troisième transistor (T_3) en vue d'une rétroaction négative de la tension de circuit.

2. Circuit oscillateur suivant la revendication 1, caractérisé par un quatrième transistor (T_4), dont la base est connectée à une tension de polarisation de base fixe et dont l'émetteur est couplé à l'émetteur du troisième transistor (T_3), les deux émetteurs étant connectés conjointement à une source de courant constant, dont le courant aux tensions de polarisation du troisième et du quatrième transistor (T_3, T_4) traverse le troisième transistor (T_3) dans une mesure suffisante pour amplifier la tension de circuit dans le premier transistor (T_1), de sorte qu'une réaction positive de la tension de circuit a lieu.

3. Circuit oscillateur suivant la revendication 2, caractérisé en ce que le collecteur de premier transistor est couplé, par l'intermédiaire d'un émetteur-suiveur (T_5), à un premier diviseur de tension (D_1, D_2, R_1-R_3), dont une première sortie (O_1) est connectée en courant alternatif à la base du deuxième transistor (T_2) et une seconde sortie (O_2) est connectée à la base du troisième transistor (T_3) et en ce qu'entre une tension d'alimentation ($1/2 V_B$) et la masse est disposé un second diviseur de tension (D_3, D_4, R_5-R_6) dont une première sortie (O_3) est couplée à la base du premier transistor (T_1) et une seconde sortie (O_4), à la base du quatrième transistor (T_4).

