

Description

Background of the Invention

The present invention relates to oscillators and, more particularly, to LC balanced oscillators.

Prior art LC balanced oscillators are well known to those skilled in the art wherein the center oscillation frequency is determined by a LC tank circuit. The prior art is replete with systems which utilize such oscillators. For example, FM receivers and television modulators use LC balanced oscillators as the local oscillators. The MC1732, an integrated circuit manufactured by Motorola Inc., is an example of a television video modulator circuit which uses a LC balanced oscillator to generate a video output signal. In this case the LC components are externally coupled to the internal oscillator components. The oscillator drives a balanced multiplier which is used as a mixer or modulator. An advantage of such balanced systems is that the oscillator signal is removed from the multiplier output.

Typically, the oscillator comprises a pair of transistors the emitters of which are commonly connected to a source of constant current. The base electrodes of the two transistors are cross-connected to the collector of the opposite transistor. The collectors are each coupled to a voltage reference source. The LC tank is coupled across the collectors of the two transistors. The output of the oscillator is taken differentially across the bases of the two transistors. A balanced multiplier comprising a pair of transistors having their emitters commonly connected to a source of current is driven by the oscillator with the differential output of the latter being connected across the base electrodes of the two transistors of the multiplier.

An oscillator as described above is shown in US-A-3963996.

Although prior art LC balance oscillators of this type work well they suffer a major problem. Any signal voltage appearing at the commonly connected emitters of the oscillator will appear at the commonly connected emitters of the transistors of the balanced multiplier. This signal will then be converted to a common mode current which flows through the two transistors. Thus, the oscillator signal developed across the tank in the prior art oscillator, assuming equal collector resistors, will produce a full wave rectified signal at twice the oscillator frequency at the emitters of the transistors of both the oscillator and multiplier. This common mode signal is highly undesirable as it can produce distortion in the modulator output signal and can decrease the conversion gain of the system.

Hence, a need exists for an improved LC balanced oscillator which eliminates or severely re-

stricts common mode signal problems associated with some prior art oscillators.

Summary of the Invention

Accordingly, the present invention seeks to provide an oscillator in which the above problem is mitigated. According to the invention there is provided a balanced oscillator including frequency determining means connected between first and second terminals, comprising:

first and second transistors each having first, second and control electrodes, said first electrodes being connected together, said control electrode of said first transistor being coupled both to the first terminal and said second electrode of said second transistor, said control electrode of said second transistor being coupled both to the second terminal and said second electrode of said first transistor said control electrodes of said first and second transistors respectively providing first and second outputs of the balanced oscillator:

a current supply circuit coupled to the first and second terminals for supplying respective independent operating currents to said first and second transistors; and

a voltage reference for supplying a predetermined and fixed voltage at said connected first electrodes of said first and second transistors.

Brief Description of the Drawings

Fig. 1 is a schematic diagram of the oscillator of the present invention; and

Fig. 2 is a detailed schematic diagram of the preferred embodiment of the invention.

Detailed Description of the Preferred Embodiment

Referring now to Fig. 1 there is illustrated balanced oscillator 10 of the present invention which is suited to be manufactured in integrated circuit form. Oscillator 10 includes a pair of NPN transistors 12 and 14 the emitters or first electrodes of which are commonly connected to a fixed voltage reference 16 such that the emitter voltage does not vary and is equal to a predetermined voltage equal to V_{REF} . The bases or control electrodes of the two transistors are cross-connected to the collector or second electrode of the opposite transistor. The cross connection of the two transistors provides positive feedback as is understood to sustain oscillation. The collectors of the two transistors are coupled in the preferred embodiment to power supply conductor 22 thorough respective resistors 18 and 20. It is understood however, that resistors 18 and 20 can be replaced, for example, by current sourcing transistors such that a source of operating

current is supplied to transistors 12 and 14. A LC tank circuit 24 is connected between the collectors of transistors 12 and 14 at terminals 26 and 28. If oscillator 10 is fabricated in integrated circuit form tank circuit 24 consisting of a discrete coil and capacitor is connected externally to the integrated circuit components. The output of oscillator 10 is taken differentially at outputs 30 and 32.

The general principle of operation of oscillator 10 is well known in that it will operate at the parallel resonant frequency of tank circuit 24. The balanced or differential output of oscillator 10 is used to switch balanced differential amplifier 34 which forms part of a balanced modulator such as described previously relating to the MC1372 video modulator circuit.

Differential amplifier 34 includes transistors 36 and 38 the respective bases of which are connected to the output of oscillator 10. The emitters of transistors 36 and 38 are differentially connected to current source 40. The collectors of transistors 36 and 38 are connected to nodes 42 and 44 which drive the multiplier portion (not shown) of the balanced modulator comprising amplifier 34.

Oscillator 10 of the present invention eliminates the common mode signal as is hereinafter described. Voltage reference 16 maintains the interconnected emitters of transistors 12 and 14 at the fixed voltage of V_{REF} such that even though the oscillator signal causes the voltages at the bases of these transistors to vary the emitters remain at V_{REF} . Thus, the voltage level established at the emitters of transistors 36 and 38 remains fixed and the common mode signal problem associated with the aforementioned prior art systems is eliminated.

Turning now to Fig. 2 oscillator 10 is illustrated in detail. Current sources 18 and 20 can be realized by current sourcing PNP transistors as is commonly practiced by those skilled in the art. Voltage reference source 16 is shown as comprising a current source 46 coupled between power supply conductor 22 and the anode of diode means 48. It is to be understood that current source 46 can also be realized by a PNP current sourcing transistor. Diode means 48, which may be formed by a diode connected transistor, has its cathode connected to the collector of transistor 50, the emitter of which is returned through a second power supply conductor to ground reference potential. A pair of series-connected resistors 52 and 54 are connected across diode means 48 with the interconnection therebetween being connected to the base of transistor 50. Diode means 48 and resistors 52 and 54 form a voltage reference means for establishing the value of the voltage V_{REF} as will be described.

In operation, current source 46 will supply a current to diode means 48 which also flows through

transistor 50. A voltage is therefore established across diode means 48 and series connected resistors 52 and 54. If diode means 48 is formed of an diode-connected transistor the voltage drop across diode means 48 is equal to V_{BE} , the base-to-emitter voltage of a standard NPN transistor. The voltage developed at the interconnection of the two resistors can be predetermined by scaling the resistor values. For example, if the resistors are of equal value, the voltage drop across each is $V_{BE}/2$. Thus, transistor 50 establishes the voltage at the interconnection of resistors 52 and 54 to be V_{BE} which due to the $V_{BE}/2$ voltage drop across resistor 54 sets the voltage at the collector of the transistor to a fixed voltage of $V_{BE}/2$. It is understood that the emitters of transistors 12 and 14 can be fixed at ground reference potential in those systems that do not require the oscillator to operate at a fixed voltage above system ground. It is the novel aspect of supplying the emitters of the two transistors of the oscillator with a low impedance fixed voltage reference that distinguishes oscillator 10 over previous systems and eliminates common mode signal injection problems associated therewith.

Although oscillator 10 is illustrated as including a pair of current sources 18 and 20, it is understood that if only one of the current sources is used, the drive to the transistors 12 and 14 will still be differential. Thus, for instance, single current source 18 could be used without current source 20 and vice versa. In addition, it is recognized that emitter follower transistors could be utilized for buffering between the collector of each of the transistors 12 and 14 and the respective base of the opposite transistor to which the collector of the one transistor is cross-connected. Hence, for example, such a buffer transistor would have its emitter connected to the base of transistor 12, its base connected to the collector of transistor 14 and its collector connected to power supply rail 22. Similarly, a second buffer transistor would have its base-emitter path connected between the collector of transistor 12 and the base of transistor 14 and its collector connected to rail 22.

A significant aspect of oscillator 10 is that, if the oscillator is formed within an integrated circuit as previously discussed, the bias currents through transistors 12 and 14 can be varied externally by adjusting $V+$ which results in the center oscillating frequency being shifted. Prior art balanced LC oscillators similar to oscillator 10 would require an extra external pin connected to the current source that is connected to the emitters of the two oscillator transistors to control the current of the current source. In many integrated circuits it may not be possible to have such an extra external pinout.

Hence, what has been described is a novel balanced LC oscillator which is used to drive bal-

anced modulators and in which common mode signal injection problems are eliminated.

Claims

1. A balanced oscillator including frequency determining means (24) connected between first (26) and second (28) terminals, comprising:

first (12) and second (14) transistors each having first, second and control electrodes, said first electrodes being connected together, said control electrode of said first transistor being coupled both to the first terminal and said second electrode of said second transistor, said control electrode of said second transistor being coupled both to the second terminal and said second electrode of said first transistor said control electrodes of said first and second transistors respectively providing first and second outputs of the balanced oscillator:

a current supply circuit (18, 20), coupled to the first and second terminals for supplying respective independent operating currents to said first and second transistors; and

a voltage reference (16) for supplying a predetermined and fixed voltage at said connected first electrodes of said first and second transistors.

2. The oscillator of claim 1 wherein said current supply circuit includes:

a first current source (18) for supplying current at an output thereof which output is connected to the first terminal; and

a second current source (20) for supplying current at an output thereof which output is connected to the second terminal.

3. The oscillator of claim 1 or 2 wherein said voltage reference includes:

a third current source (46) for supplying a current at an output:

a third transistor (50) having first, second and control electrodes, said first electrode being adapted to receive a ground reference potential; and

voltage determining circuitry (48, 52, 54) connected to said output of said third current source (46) and said second and control electrodes of said third transistor (50) for establishing said fixed voltage at the second electrode of said third transistor.

4. The oscillator of claim 3 wherein said voltage determining circuit includes:

a diode (48) coupled between said output of said third current source (46) and said sec-

ond electrode of said third transistor (50); and first (52) and second (54) series connected resistors coupled between said output of said third current source and said second electrode of said third transistor, said control electrode of said third transistor being coupled to the interconnection of said first and second resistors.

5. The oscillator of any one of claims 1 to 4 and integrated on a monolithic chip.

6. A balanced modulator having first (30) and second (32) inputs and including an oscillator (10) according to any preceding claim for providing a differential oscillator signal at the first and second inputs.

Patentansprüche

1. Ein symmetrischer Oszillator mit Mitteln zur Frequenzeinstellung (24), die zwischen einem ersten (26) und zweitem (28) Anschluß liegen, ferner mit:

einem ersten (12) und zweiten (14) Transistor, von denen jeder eine erste, zweite und Steuerelektrode besitzt, wobei besagte erste Elektroden miteinander verbunden sind, besagte Steuerelektrode des besagten ersten Transistors ist sowohl an den ersten Anschluß als auch an besagte zweite Elektrode des besagten zweiten Transistors gekoppelt, besagte Steuerelektrode des besagten zweiten Transistors ist sowohl an den zweiten Anschluß als auch an besagte zweite Elektrode des besagten ersten Transistors gekoppelt, besagte Steuerelektroden des besagten ersten bzw. zweiten Transistors bilden den ersten und zweiten Ausgang des symmetrischen Oszillators;

einer Stromversorgungsschaltung (18, 20), gekoppelt an den ersten und zweiten Anschluß, zur Versorgung der entsprechenden unabhängigen Betriebsströme für besagten ersten und zweiten Transistor; und

einer Spannungsreferenz (16) zur Versorgung einer vorbestimmten und festen Spannung an besagten miteinander verbundenen ersten Elektroden des besagten ersten und zweiten Transistors.

2. Der Oszillator nach Anspruch 1, worin besagte Stromversorgungsschaltung folgendes beinhaltet:

eine erste Stromquelle (18) zur Stromversorgung an einem ihrer Ausgänge, welcher an den ersten Anschluß angeschlossen ist; und

eine zweite Stromquelle (20) zur Stromversorgung an einem ihrer Ausgänge, welcher an



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Claims

1. A balanced oscillator including frequency determining means (24) connected between first (26) and second (28) terminals, comprising:

first (12) and second (14) transistors each having first, second and control electrodes, said first electrodes being connected together, said control electrode of said first transistor being coupled both to the first terminal and said second electrode of said second transistor, said control electrode of said second transistor being coupled both to the second terminal and said second electrode of said first transistor said control electrodes of said first and second transistors respectively providing first and second outputs of the balanced oscillator:

a current supply circuit (18, 20), coupled to the first and second terminals for supplying respective independent operating currents to said first and second transistors; and

a voltage reference (16) for supplying a predetermined and fixed voltage at said connected first electrodes of said first and second transistors.

2. The oscillator of claim 1 wherein said current supply circuit includes:

a first current source (18) for supplying current at an output thereof which output is connected to the first terminal; and

a second current source (20) for supplying current at an output thereof which output is connected to the second terminal.

3. The oscillator of claim 1 or 2 wherein said voltage reference includes:

a third current source (46) for supplying a current at an output:

a third transistor (50) having first, second and control electrodes, said first electrode being adapted to receive a ground reference potential; and

voltage determining circuitry (48, 52, 54) connected to said output of said third current source (46) and said second and control electrodes of said third transistor (50) for establishing said fixed voltage at the second electrode of said third transistor.

4. The oscillator of claim 3 wherein said voltage determining circuit includes:

a diode (48) coupled between said output of said third current source (46) and said sec-

ond electrode of said third transistor (50); and

first (52) and second (54) series connected resistors coupled between said output of said third current source and said second electrode of said third transistor, said control electrode of said third transistor being coupled to the interconnection of said first and second resistors.

5. The oscillator of any one of claims 1 to 4 and integrated on a monolithic chip.

6. A balanced modulator having first (30) and second (32) inputs and including an oscillator (10) according to any preceding claim for providing a differential oscillator signal at the first and second inputs.

Patentansprüche

1. Ein symmetrischer Oszillator mit Mitteln zur Frequenzeinstellung (24), die zwischen einem erstem (26) und zweitem (28) Anschluß liegen, ferner mit:

einem ersten (12) und zweiten (14) Transistor, von denen jeder eine erste, zweite und Steuerelektrode besitzt, wobei besagte erste Elektroden miteinander verbunden sind, besagte Steuerelektrode des besagten ersten Transistors ist sowohl an den ersten Anschluß als auch an besagte zweite Elektrode des besagten zweiten Transistors gekoppelt, besagte Steuerelektrode des besagten zweiten Transistors ist sowohl an den zweiten Anschluß als auch an besagte zweite Elektrode des besagten ersten Transistors gekoppelt, besagte Steuerelektroden des besagten ersten bzw. zweiten Transistors bilden den ersten und zweiten Ausgang des symmetrischen Oszillators;

einer Stromversorgungsschaltung (18, 20), gekoppelt an den ersten und zweiten Anschluß, zur Versorgung der entsprechenden unabhängigen Betriebsströme für besagten ersten und zweiten Transistor; und

einer Spannungsreferenz (16) zur Versorgung einer vorbestimmten und festen Spannung an besagten miteinander verbundenen ersten Elektroden des besagten ersten und zweiten Transistors.

2. Der Oszillator nach Anspruch 1, worin besagte Stromversorgungsschaltung folgendes beinhaltet:

eine erste Stromquelle (18) zur Stromversorgung an einem ihrer Ausgänge, welcher an den ersten Anschluß angeschlossen ist; und

eine zweite Stromquelle (20) zur Stromversorgung an einem ihrer Ausgänge, welcher an



den zweiten Anschluß angeschlossen ist.

3. Der Oszillator nach Anspruch 1 oder 2, worin besagte Spannungsreferenz folgendes beinhaltet:

eine dritte Stromquelle (46) zur Stromversorgung an einem Ausgang;

einen dritten Transistor (50), der eine erste, eine zweite und eine Steuerelektrode besitzt, wobei besagte erste Elektrode angepaßt ist, um ein Erdreferenzpotential zu erhalten; und

eine Schaltung zur Festlegung einer Spannung (48, 52, 54), die verbunden ist mit besagtem Ausgang der besagten dritten Stromquelle (46) und besagter zweiter Elektrode und Steuerelektrode des besagten dritten Transistors (50) zur Schaffung besagter fester Spannung an der zweiten Elektrode des besagten dritten Transistors.

4. Der Oszillator nach Anspruch 3, worin besagte Schaltung zur Festlegung einer Spannung folgendes beinhaltet:

eine Diode (48) gekoppelt zwischen besagtem Ausgang der besagten dritten Stromquelle (46) und besagter zweiter Elektrode des besagten dritten Transistors (50); und

einen ersten (52) und zweiten (54) in Serie verbundenen Widerstand gekoppelt zwischen besagtem Ausgang der besagten dritten Stromquelle und besagter zweiter Elektrode des besagten dritten Transistors, wobei besagte Steuerelektrode des besagten dritten Transistors mit dem Verbindungspunkt des besagten ersten und zweiten Widerstandes verbunden ist.

5. Der Oszillator nach wenigstens einem der Ansprüche 1 bis 4 integriert auf einem Halbleiterbaustein.

6. Ein Gegentaktmodulator, der einen ersten (30) und zweiten (32) Eingang hat und einen Oszillator (10) nach wenigstens einem der vorangehenden Ansprüche beinhaltet, zur Erzeugung eines differentiellen Oszillatorsignals am ersten und zweiten Eingang.

Revendications

1. Oscillateur équilibré incluant un moyen de détermination de fréquence (24) connecté entre des première (26) et seconde (28) bornes, comprenant:

des premier (12) et second (14) transistors comportant chacun des première et seconde électrodes et une électrode de commande, les-

dites premières électrodes étant connectées ensemble, ladite électrode de commande dudit premier transistor étant couplée à la fois à la première borne et à ladite seconde électrode dudit second transistor, ladite électrode de commande dudit second transistor étant couplée à la fois à la seconde borne et à ladite seconde électrode dudit premier transistor, lesdites électrodes de commande desdits premier et second transistors fournissant respectivement des premier et second signaux de sortie de l'oscillateur équilibré;

un circuit de fourniture de courant (18,20), couplé aux première et seconde bornes pour fournir des courants de fonctionnement indépendants respectifs auxdits premier et second transistors; et

une source de tension de référence (16) pour fournir une tension prédéterminée fixe auxdites premières électrodes connectées desdits premier et second transistors.

2. Oscillateur selon la revendication 1, dans lequel ledit circuit de fourniture de courant comprend:

une première source de courant (18) pour fournir un courant à sa sortie, cette sortie étant connectée à la première borne; et

une seconde source de courant (20) pour fournir un courant à sa sortie, cette sortie étant connectée à la seconde borne.

3. Oscillateur selon l'une quelconque des revendications 1 et 2, dans lequel ladite source de tension de référence comprend:

une troisième source de courant (46) pour fournir un courant à une sortie;

un troisième transistor (50) comportant des première et seconde électrodes et une électrode de commande, ladite première électrode étant adaptée pour recevoir un potentiel de masse de référence; et

des circuits de détermination de tension (48,52,54) connectés à ladite sortie de ladite troisième source de courant (46) et à ladite seconde électrode et ladite électrode de commande dudit troisième transistor (50) pour établir ladite tension fixe à la seconde électrode dudit troisième transistor.

4. Oscillateur selon la revendication 3, dans lequel lesdits circuits de détermination de tension comprennent:

une diode (48) couplée entre ladite sortie de ladite troisième source de courant (46) et ladite seconde électrode dudit troisième transistor (50); et

des première (52) et seconde (54) résis-



tances connectées en série, couplées entre ladite sortie de ladite troisième source de courant et ladite seconde électrode dudit troisième transistor, ladite électrode de commande dudit troisième transistor étant couplée à l'interconnexion desdites première et seconde résistances.

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5. Oscillateur selon l'une quelconque des revendications 1 à 4, qui est intégré sur une puce monolithique.

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6. Modulateur équilibré comportant des première (30) et seconde (32) entrées et incluant un oscillateur (10) selon l'une quelconque des revendications 1 à 5, pour fournir un signal différentiel d'oscillateur aux première et seconde entrées.

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