

Description**Technical Field**

5 This invention relates generally to electronic oscillators and more particularly to improvements in electronic oscillators of the Colpitts and/or Clapp type.

Background Art

10 The Colpitts and Clapp oscillators are well known for having good properties in the communications field. However, at ultra high frequencies (above about 500 MHz) the tuning range, the tuning linearity, power output flatness, and noise performance become greatly degraded. The current state of the art has been to accept a limited tuning range and then use multiple oscillators to cover wide bands and to use filtered and amplified harmonics of lower frequency oscillators to achieve acceptable power flatness and phase noise performance.

15 The Colpitts oscillator is described in U. S. Patent No. 1,624,537. Bell U. S. Patent No. 2,225,897 discloses a parallel resonant tuned circuit between the grid and plate of a vacuum tube and a capacitor between the grid and one side of the tuned circuit but does not have means in the feedback loop to control the phase shift. Blum U. S. Patent No. 2,756,334 discloses a parallel resonant tuned circuit between the grid and plate of a vacuum tube and a capacitor between the grid and one side of the tank circuit but, like Bell, has no way to control the phase shift in the feedback loop for the tank circuit. U.S. Patent No. 3,675,109 discloses a Colpitts oscillator with the addition of a resistance between the amplifier and the junction of the tank capacitors.

Summary of the Invention

20 In accordance with the present invention there is provided a wideband electronic oscillator comprising:
a resonant tank circuit including an inductance means, a main capacitance and second and third capacitors connected in series with one another for producing oscillations;

30 a signal amplifier for overcoming losses to sustain oscillations in the tank circuit, said amplifier having an input and an output, said amplifier amplifying a signal in a power output path and also providing a feedback signal from its output, which feedback signal is fed back to the input of the amplifier via part of the tank circuit which part includes one of said second and third capacitors;

a first impedance connected between said output and ground;

35 a second impedance connected from a point between said second and third capacitors to said output; characterised in that:

40 said second impedance includes a reactance for maintaining the phase shift of the feedback signal between the input and output of said amplifier at substantially zero degrees and for reducing noise components near the oscillating frequency, said second impedance having a high value at low frequencies in relation to the first impedance so that the low frequency noise components are dissipated in said first impedance, said second impedance also reducing the loading of said first impedance on said tank circuit to raise the Q and thereby improve the stability of the oscillations in said tank circuit. This circuit arrangement has been found to improve the tuning range, tuning linearity, and phase noise performance, as well as providing a very flat power output at ultra high frequencies (above about 500 MHz).

Brief Description of Drawings

45 Certain embodiments of this invention will be described by way of example in connection with the accompanying drawings, in which:

50 Figure 1 is a schematic circuit diagram of an oscillator embodying features of the present invention;

Figure 2 is a schematic circuit diagram of a modification of the oscillator shown in Figure 1;

Figure 3 is a schematic circuit diagram of another modification of the oscillator shown in Figure 1;

Figure 4 is a schematic circuit diagram of yet another modification of the oscillator shown in Figure 1;

Figure 5 is a schematic circuit diagram of a further modification of the oscillator shown in Figure 1;

55 Figure 6 is a schematic circuit diagram of still another modification of the oscillator shown in Figure 1;

Figure 7 is a schematic circuit diagram of an oscillator according to the present invention using transmission line sections;

Figure 8 shows an alternative power output for the oscillator of Figure 1; and

Figure 9 shows another alternative power output for the oscillator of Figure 1.

Detailed Description

Referring now to Figure 1, there is shown an oscillator which includes a series resonant tuned tank circuit comprised of a main resonating inductor L1, a main tuning capacitor C1, shown as a varactor diode, a DC blocking capacitor C2, and feedback signal divider capacitors C3 and C4 connected in series. Capacitor C2 is not essential when C1 is a varactor diode but its use, connected as shown, is preferred. The side of the inductor L1 opposite its connection to capacitor C1 is shown connected to ground. The side of the divider capacitor C4 opposite its connection to capacitor C3 is shown connected to ground.

Inductor L1, which serves as the inductance means for the tank circuit, may be a variable inductor used to change the resonant frequency of the tank circuit. In this instance capacitor C1 would be a fixed value and preferably there would be no C2. The inductance means may also be a tuned cavity or crystal resonator. A crystal resonator would provide similar results except for the wider tuning range. However, the tuning range would be wide as compared with other crystal oscillators.

A DC voltage tuning input terminal VT is connected through a resistor R5 to tuning capacitor C1 to bias capacitor C1. More specifically, terminal VT supplies a positive tuning voltage at the cathode electrode with respect to the anode electrode of varactor diode C1. Resistor R5 is of a high value so as not to load the Q of the tank circuit. Resistor R5 may be an RF choke, a high impedance active device such as a transistor, or another network presenting a high RF impedance and a controlled DC resistance.

An RF bypass capacitor C6 is connected to input terminal VT and to ground to provide a low pass filter and thereby short out any RF signals. Capacitor C6 is a low reactance at minimum oscillator frequencies and a high reactance at maximum anticipated modulation frequencies.

The feedback loop for sustaining the oscillations in the tank circuit includes feedback signal dividing capacitor C3, an amplifier A, and an impedance in the form of a capacitor C5 connected to point D between capacitors C3 and C4 and to the feedback output of the amplifier A at point E. Amplifier A as shown is an active device and specifically is an NPN transistor having the base and emitter electrodes connected in the feedback loop. Other active devices such as a FET or a vacuum tube may be used in place of a transistor. The prior art Colpitts oscillator has a direct connection or short where capacitor C5 is connected which results in a less desirable performance, as is discussed more fully hereinafter.

A feedback output impedance in the form of a resistor R4 is shown connected between the transistor emitter which is the feedback output of the amplifier, designated point E, and ground. Resistor R4 may be replaced with a choke, an output transformer, a filter or other network which looks like a high impedance at RF frequencies, and a controlled bias impedance to DC.

A DC voltage supply terminal VS is connected through a resistor R3 and an inductor L2 to the collector electrode of the transistor to supply a DC feed voltage thereto. A resistor R1 is connected to inductor L2 and to the base of the transistor to connect resistor R1 and inductor L2 between the base and collector electrodes of the transistor. Resistor R2 is connected to the base of the transistor and to ground. In this way resistors R1 and R2 are selected to provide the proper DC bias for the transistor and are selected to have a sufficiently large value so as not to degrade the Q of the tuned circuit. Resistors R1 and R2 may be replaced with other networks such as chokes or may be absent as required to provide the proper bias conditions for the transistor.

The power output is shown as being taken from the collector of the transistor. An AC output coupling and impedance matching arrangement is connected to the collector of the transistor and to a power output terminal PO which includes a capacitor C9 between the collector and power output terminal PO, inductor L2 coupled to the collector, and an RF bypass capacitor C8 connected to the inductor L2, resistor R1 and resistor R3 and ground to provide an RF ground.

The output coupling and impedance matching can be accomplished in a number of ways which include changing L2 to a choke, resistor, filter, or other network which matches the active device to the desired output load. A load L is shown connected to the PO terminal. It is understood that the output power can be taken from other points in the circuit, as is discussed more fully hereinafter.

In the operation of the above described oscillator the LC resonant tank circuit oscillates at a frequency

$$F = \frac{1}{2\pi\sqrt{LXC \text{ total}}}$$

C is the total capacitance in the tuned circuit. A portion of the feedback output of the amplifier A is applied in phase to the tank circuit and to the input of amplifier A to sustain oscillations.

In order not to reduce the effective value of C1, and thereby reduce tuning range, C2 should be much greater in value than C1. Values of C2 equal to ten to twenty times greater than a maximum value of C1 are typical. Capacitor C2 could be replaced by a conductor in applications where capacitor C1 is a mechanical DC isolated capacitor itself or, conversely, C1 is a fixed DC isolated value and inductor L1 is varied to change the resonant frequency of the oscillator.

Capacitor C3 functions to provide a return path for the resonant circuit energy from point C to point D and provides a feedback path for feedback energy developed by the transistor from point D to point C.

The value of C3 must be chosen in conjunction with the rest of the tuned circuit capacitors to provide the proper voltage to ground which is the point C to ground tap point on the tuned circuit to insure that the transistor is commutated through a sufficient dynamic range to develop enough feedback voltage, at point E to ground, to sustain the criteria for oscillations over the entire intended tuning range of the oscillator. Values of C3 equal to two to ten times the value of capacitor C1 are typical.

Capacitor C4, like capacitor C3, forms a return path for the resonant circuit from point D to ground. The value of C4 must be chosen in conjunction with the rest of the tuned circuit capacitors to provide the proper voltage to ground, which is the point C to ground tap point on the tuned circuit, to insure that the transistor is commutated through enough dynamic range to develop sufficient feedback voltage, at point E to ground, to sustain the criteria for oscillations over the entire intended tuning range of the oscillator. Values of C4 equal to two to ten times the value of capacitor C1 are typical.

Capacitor C4 also functions as a part of the return path for energy generated at point E to ground. In this sense, it functions as an RF bypass and has a primary effect on transistor gain over the tuning range. Capacitor C4, along with capacitor C3, sets the tap point D to ground voltage on the tuned circuit and controls the amount of feedback voltage applied to point C from point D generated by the transistor at point E by its commutation through its dynamic range. The tuning range for the oscillator may be approximated by (a) neglecting all stray and interelectrode capacitances of the transistor, (b) neglecting all stray series resistances, inductances and capacitances, (c) neglecting all stray shunt circuit capacitances between elements and to ground.

$$C2 \approx 20 \times C1 \text{ max}$$

$$C3 \approx 5 \times C1 \text{ max}$$

$$C4 \approx 5 \times C1 \text{ max}$$

The expression for CT max (CTotal) in the series tuned circuit would calculate out to:

$$CT \text{ max} \approx .69 \times C1 \text{ max}$$

Similarly, for values of C1 maximum < C2, C3, C4 i.e., large capacitor tuning ratios)

$$CT \text{ minimum} \approx C1 \text{ minimum.}$$

With modern tuning capacitors, electrically or mechanically variable, ranges of C maximum to C minimum of 15:1 to 20:1 are available. The frequency of the oscillator is inversely proportional to $\sqrt{C}$. The total possible frequency tuning range with a capacitor with a tuning ratio of C maximum to C minimum = 15 is given by the ratio:

$$\begin{aligned} \text{Frequency tuning} &= \sqrt{\frac{.69 \times C1 \text{ max}}{C1 \text{ max}}} \\ &= \sqrt{10.35} \\ &= 3.21:1 \end{aligned}$$

In the Colpitts oscillator without C5, when C3 and C4 are selected to provide a wide tuning ratio, as demonstrated above, i.e., 2-10 x C1 maximum, the capacitance to ground is found to be too large at point

E. That is, when C3, C4 are selected for wide tuning ranges in the Colpitts oscillator, the oscillator output tends to be very nonflat, and oscillations typically cease over the upper half of the tuned band. If C3 and C4 are made smaller in the Colpitts oscillator, oscillations are maintained with the result that the tuning range is typically reduced to

$$\frac{F_{\text{Maximum}}}{F_{\text{Minimum}}} < < 2:1$$

The root cause for this condition is threefold: At very high frequencies the intercomponent inductances and active device interelectrode capacitances form parasitic paths or resonances. These may occur in-band and cause conventional oscillator circuits to fail, typically at the upper end of the tuning band, thus limiting available tuning range. For example, in the Colpitts oscillator, collector to emitter capacitance in series with C4 can series resonate with stray interconnecting inductances to effectively RF-short the transistor collector to ground and cause oscillations to cease.

In a like manner, the base to emitter capacitance in series with C4 can series resonate with stray interconnecting inductances to effectively short the transistor input to ground.

Similarly, in the Colpitts oscillator capacitor C3 would be connected directly between the base and the emitter, and a resonant current through interconnecting inductances can flow in circular fashion through the transistor base to emitter capacitance and back around through C3. This condition causes the transistor input to appear as a high impedance circuit and little power can be transmitted from the tuned circuit into this mismatch to commutate the transistor to achieve oscillations. All three conditions above of spurious resonances have been isolated and observed in the Colpitts oscillator to cause oscillations to cease and/or output power to vary widely over the band.

In addition, the ability of these parasitic resonances to cause undesired circuit operation is not simply traceable to pure shorting or open conditions. For example, parasitic resonances, well out of the oscillator intended tuning band, are seen to adversely affect proper operation. This condition results from disadvantageous phase shifts applied to the normal voltages and currents flowing in the transistor circuit. This is due to the transfer phase characteristics of the parasitic resonant circuits. For example, a positive voltage applied to the transistor base at point C is assumed to produce a corresponding voltage at point E minus a small base to emitter voltage drop in the transistor. This emitter voltage should be in phase with applied base voltage to produce proper transistor power amplification and feedback action.

As seen in the three parasitic resonance examples above, the voltage developed at point E may experience a phase shift due to the parasitic LRC circuits and thus not be applied to the feedback path in the proper phase to cause positive feedback. Hence, it will not sustain the desired regenerative buildup of oscillations.

The main tuned circuit by definition allows the current flow and voltage to be precisely in phase only near the

$$F = \frac{1}{2\pi\sqrt{L \times C_{\text{total}}}}$$

oscillation frequency. Since the transistor base currents and voltages are applied in phase to the base only at the normal frequency of resonance, then the voltage and current developed at point E (the emitter) must remain of equal phases in order that feedback voltage from point E to the base via the dividing capacitors C3 and C4 is itself in phase with the original base input signal and, hence, positive feedback.

Since the emitter circuit forms a part of a parasitic tuned circuit at an entirely different (higher) frequency, the voltage and current at the desired resonance frequency are now of differing phase and, when applied to point C through the capacitor C3, do not constitute a positive feedback signal at the proper resonant frequency within the bandwidth of the tuned circuit, and oscillations cease, as previously outlined.

The present invention overcomes the above shortcomings of the Colpitts oscillator by introduction of an additional impedance in the path between point E and the feedback divider capacitors at point D. In the circuit of the present invention capacitors C3 and C4 are selected to optimize tuning range (as large as possible) consistent with proper impedance match to the input of the transistor, independently of their effect of causing troublesome parasitic resonance or parasitic phase shift effects on the emitter and feedback

voltages and currents, as earlier discussed.

The reactance network represented by capacitor C5 from point E to point D is selected to yield proper gain of the transistor, feedback amplitude and phase shift characteristics to the feedback energy independently of the values of C3 and C4 previously optimized as outlined. Typically, values of

$$C5 = \frac{C4}{2} \text{ to } C5 = C4$$

have been used to cause a circuit that would not operate properly over more than a 30% tuning range to operate with flat output over a 3:1 tuned frequency range. The parasitic series resonance return paths to ground now see:

$$C_{\text{Return}} = \frac{C5 \cdot C4}{C5 + C4}$$

instead of

$$C_{\text{Return}} = C4 \text{ in the Colpitts oscillator.}$$

If $C5 = \frac{1}{2} C4$, then

$$C_{\text{Return}} = \frac{\left(\frac{C4}{2}\right) \cdot C4}{\frac{C4}{2} + C4}$$

$$C_{\text{Return}} = \frac{C4}{3}$$

This is to say that the troublesome parasitic series resonances and/or phase shifts have been moved substantially higher in frequency (reduced phase shift at the oscillator frequency) corresponding to a ground return capacitance, which is now typically one-third of a typical original value in the standard Colpitts circuit.

Similarly, since in a typical Colpitts circuit $C4 = C3$, the circulating resonance path from emitter to base through C3 is likewise seen to be moved up in frequency (well out of band) corresponding to a circulating return emitter to base capacitance reduced to one-third of the Colpitts oscillator value.

In like manner, the troublesome emitter circuit phase shifts associated with the large original values of C3 and C4, in conjunction with other circuit strays, are seen to be substantially reduced. This allows sustained oscillations within the circuit at much higher frequencies and thereby yields much wider tuning ranges.

The use of the additional network between points E and D in the present circuit produces further benefits as follows:

(1) The emitter DC return point E to ground is always some finite impedance (R4, a resistance in Figure 1) and appears directly across C4 to ground in the Colpitts oscillator and thereby appears across a portion of the tuned circuit capacitance C4. This constitutes a load upon the tuned tank circuit, which tends to lower its Q and reduce overall stability associated with a desirable high circuit Q. The introduction of capacitor C5 causes resistor R to be an undesired load on the tank circuit through capacitor C5 so as to isolate resistor R4 from the tuned tank circuit by virtue of its series reactance and raise the circuit loaded Q and thereby improves the stability of the oscillations in the tank circuit.

(2) A portion of the power produced by commutation of the transistor at point E is fed back to the transistor in phase through capacitor C3 to the transistor base to cause oscillations. A necessary consequence of circuit and transistor action is the undesired production of noise spikes which, upon being fed back, tend to modulate the transistor and the voltage tuned capacitor to cause phase modulation of the desired oscillating frequency. Typically, the loaded Q of the tuned circuit is not sufficiently high to completely filter this noise which appears along with the useful output power as both AM noise and FM (phase) noise.

In the present invention, noise components near the oscillating frequency are reduced in amplitude in the feedback path by virtue of the voltage drop across C5 from point E to point D. By virtue of the voltage divider, consisting of capacitors C5 and C4 to ground, C4 was chosen, as above discussed, to have a larger value than allowed in the Colpitts oscillator. This improves the reduction in noise components. Improve-

ments in near-in phase noise of six to ten decibels have been measured in a circuit according to the present invention, compared to the Colpitts oscillator.

In addition, low frequency noise components, either generated within the circuit or present from the external power supply, are filtered to ground by being partially dissipated in resistor R4 by virtue of capacitor C5 in conjunction with resistor R4, providing a low pass filtering action. Low frequency noise energy, which appears at point E, is presented with a very high impedance to the feedback path through capacitor C5 and a much lower impedance to ground through resistor R4. Hence, low frequency noise is effectively filtered in the circuit of the present invention from the feedback path by a greater amount than in the Colpitts oscillator where the low frequency noise is presented directly to point D in the tuned circuit.

The modified oscillator shown in Figure 2 has another varactor diode C10 connected in series with varactor diode C1 with the cathodes of the two connected together. A DC return resistor R6 is connected to the anode of varactor diode C10. This circuit tends to reduce the harmonic generation in the varactor diodes.

Referring to Figure 3, a varactor diode C11 is connected in series with varactor diode C1 with the cathodes of the two connected together. The anode of varactor diode C11 is connected to ground. At the low end of the band the tuned circuit functions in a parallel resonant mode, C1 together with C11 being the main tuning capacitors and C2 simply coupling energy to the transistor. At the high end of the band C11 is much less than the capacitance of the rest of the circuit and the circuit transitions to a series resonant circuit where C1 is now the main resonant capacitor and the overall oscillator tuning range is increased.

The modified circuit shown in Figure 4 includes a tuned series resonant circuit that is tuned and ganged to the resonant tank circuit. This circuit consists of an inductor L3 and a varactor diode C12 connected between capacitor C5 and point D, together with a choke RFC connected between capacitor C5 and ground. An additional resistor R7 is added between point D and terminal VT. In this circuit the value of resistor R5 is typically equal to the value of resistor R7 and the capacitance of capacitor C1 is equal to the capacitance of capacitor C12.

This circuit is ganged to and adjusted to track the resonant frequency of the tuned circuit. This added tuned circuit filters the feedback signal, that is, it only allows the transistor to have maximum gain at the fundamental oscillator frequency and thereby functions as a tuned bandpass feedback filter. In this way harmonics and out-of-band noise are effectively attenuated in the oscillator output relative to the desired oscillator frequency. Since the current and voltage are in phase in a series resonant circuit at resonance, this tuned circuit, when properly aligned has no effect on the transfer phase of the circuit from point D to point E.

The stability of this circuit relative to phase shifts associated with pushing, pulling, and AM/FM noise modulation is improved by virtue of the increased phase shift character of the tandem tuned circuit as well as the filtering action realized in the feedback circuit.

It will be noted that a capacitor may be connected across resistor R4, as is described in Figure 5, but this is optional for the circuit of Figure 4. The added capacitor would improve the Q of the main tuned circuit by effectively shunting the value of R4 with a relatively lossless element.

Other alternative impedance networks which could be connected between points D and E include a series RC network, a parallel RC network and a transformer network with the transformer primary and a capacitor connected in series between points D and E and the output PO taken from the transformer secondary.

The modified circuit shown in Figure 5 has a capacitor C7 connected across resistor R4. This addition of C7 allows the adjustment of the transistor gain independently from the adjustment of the feedback impedance. Further, C7 changes the Q loading on the tuned circuit to the extent that there are improved stability and a higher performance that come with an associated higher Q value for the tuned circuit. Improvements in a loaded Q of a ratio of 2:1 have been realized as compared with that of the Colpitts oscillator.

A further modification for Figure 5 would be to add an inductor between point E and resistor R4 which would improve low frequency noise immunity. This inductor may be chosen to look like a high impedance over the oscillator band and a low reactance at low frequencies. Capacitor C7 may be chosen to look like a high reactance at low noise frequencies. This circuit would short out feedback to the tuned circuit and transistor of low frequency noise and thus prevent such noise from appearing amplified in the output as AM noise or FM modulation of the output.

A further modification shown in Figure 6 would be to add a capacitor C13 in the feedback loop between the base of the transistor and point C. This added capacitor would similarly be used to maintain proper impedance matching and proper phase relationships.

Referring now to Figure 7, there is shown a transmission line section TL1 in place of inductor L1, a

transmission line section TL2 in place of capacitor C4, and a transmission line section TL3 connected to resistor R4, together with a transmission line section TL4 in place of L2. This circuit would operate in the high microwave frequency range.

An alternative power output circuit, shown in Figure 8, has the power output terminal coupled to resistor R4 through a coupling capacitor C14.

Another arrangement for the power output terminal PO, which is shown in Figure 9, is to have it coupled to inductor L1 of the resonant tank circuit. The coupling shown includes an amplifier circuit which, as shown, is an emitter follower circuit having a transistor T with its base coupled to inductor L1 through capacitor C15. A bias resistor R11 is connected between the base of the transistor and the VS terminal. A bias resistor R12 is connected between the base and ground. Resistor R13 is connected between the emitter and ground. An RF bypass capacitor C16 is connected to resistor R11 and terminal VS. A coupling capacitor C17 is connected between the emitter and output terminal PO. The load L is shown connected across output terminal PO.

Claims

1. A wideband electronic oscillator comprising:

a resonant tank circuit including an inductance means (L1), a main capacitance (C1) and second and third capacitors (C3,C4) connected in series with one another for producing oscillations;

a signal amplifier (A) for overcoming losses to sustain oscillations in the tank circuit, said amplifier having an input and an output, said amplifier amplifying a signal in a power output path and also providing a feedback signal from its output, which feedback signal is fed back to the input of the amplifier via part of the tank circuit which part includes one of said second and third capacitors (C3,C4);

a first impedance (R4) connected between said output and ground;

a second impedance connected from a point between said second and third capacitors to said output; characterised in that:

said second impedance includes a reactance (C5) for maintaining the phase shift of the feedback signal between the input and output of said amplifier (A) at substantially zero degrees and for reducing noise components near the oscillating frequency, said second impedance (C5) having a high value at low frequencies in relation to the first impedance (R4) so that the low frequency noise components are dissipated in said first impedance (R4), said second impedance (C5) also reducing the loading of said first impedance on said tank circuit to raise the Q and thereby improve the stability of the oscillations in said tank circuit.

2. An oscillator as claimed in claim 1 wherein said second impedance comprises a capacitance (C5).

3. An oscillator as claimed in claim 1 or 2 wherein said main capacitance comprises a tuning capacitor.

4. An oscillator as claimed in claim 3 wherein said main capacitance comprises a varactor diode.

5. An oscillator as claimed in claim 4 including a voltage tuning input terminal to supply a positive tuning voltage at a cathode electrode of said varactor diode with respect to an anode electrode of said varactor diode.

6. An oscillator as claimed in any preceding claim wherein said amplifier is an active device in the form of a transistor having a base and an emitter connected in said feedback loop.

7. An oscillator as claimed in claim 6 wherein said base is coupled to said main capacitance and to said one of said second and third capacitors.

8. An oscillator as claimed in claim 6 or 7 wherein said emitter is connected to said first impedance.

9. An oscillator as claimed in any preceding claim wherein said first impedance is a resistor.

10. An oscillator as claimed in any preceding claim wherein the capacitance of said capacitors in said resonant tank circuit, excluding said main capacitance, is relatively large with respect to the capacitance of said main capacitance so that the resonant frequency of the tank circuit is primarily dependent



transmission line section TL2 in place of capacitor C4, and a transmission line section TL3 connected to resistor R4, together with a transmission line section TL4 in place of L2. This circuit would operate in the high microwave frequency range.

An alternative power output circuit, shown in Figure 8, has the power output terminal coupled to resistor R4 through a coupling capacitor C14.

Another arrangement for the power output terminal PO, which is shown in Figure 9, is to have it coupled to inductor L1 of the resonant tank circuit. The coupling shown includes an amplifier circuit which, as shown, is an emitter follower circuit having a transistor T with its base coupled to inductor L1 through capacitor C15. A bias resistor R11 is connected between the base of the transistor and the VS terminal. A bias resistor R12 is connected between the base and ground. Resistor R13 is connected between the emitter and ground. An RF bypass capacitor C16 is connected to resistor R11 and terminal VS. A coupling capacitor C17 is connected between the emitter and output terminal PO. The load L is shown connected across output terminal PO.

15 Claims

1. A wideband electronic oscillator comprising:

a resonant tank circuit including an inductance means (L1), a main capacitance (C1) and second and third capacitors (C3,C4) connected in series with one another for producing oscillations;

a signal amplifier (A) for overcoming losses to sustain oscillations in the tank circuit, said amplifier having an input and an output, said amplifier amplifying a signal in a power output path and also providing a feedback signal from its output, which feedback signal is fed back to the input of the amplifier via part of the tank circuit which part includes one of said second and third capacitors (C3,C4);

a first impedance (R4) connected between said output and ground;

a second impedance connected from a point between said second and third capacitors to said output; characterised in that:

said second impedance includes a reactance (C5) for maintaining the phase shift of the feedback signal between the input and output of said amplifier (A) at substantially zero degrees and for reducing noise components near the oscillating frequency, said second impedance (C5) having a high value at low frequencies in relation to the first impedance (R4) so that the low frequency noise components are dissipated in said first impedance (R4), said second impedance (C5) also reducing the loading of said first impedance on said tank circuit to raise the Q and thereby improve the stability of the oscillations in said tank circuit.

2. An oscillator as claimed in claim 1 wherein said second impedance comprises a capacitance (C5).

3. An oscillator as claimed in claim 1 or 2 wherein said main capacitance comprises a tuning capacitor.

4. An oscillator as claimed in claim 3 wherein said main capacitance comprises a varactor diode.

5. An oscillator as claimed in claim 4 including a voltage tuning input terminal to supply a positive tuning voltage at a cathode electrode of said varactor diode with respect to an anode electrode of said varactor diode.

6. An oscillator as claimed in any preceding claim wherein said amplifier is an active device in the form of a transistor having a base and an emitter connected in said feedback loop.

7. An oscillator as claimed in claim 6 wherein said base is coupled to said main capacitance and to said one of said second and third capacitors.

8. An oscillator as claimed in claim 6 or 7 wherein said emitter is connected to said first impedance.

9. An oscillator as claimed in any preceding claim wherein said first impedance is a resistor.

10. An oscillator as claimed in any preceding claim wherein the capacitance of said capacitors in said resonant tank circuit, excluding said main capacitance, is relatively large with respect to the capacitance of said main capacitance so that the resonant frequency of the tank circuit is primarily dependent



on the value of said main capacitance.

11. An oscillator as claimed in claim 10 wherein said resonant frequency tuning range is greater than the ratio of 3:1.
12. An oscillator as claimed in any preceding claim wherein the value of said second impedance is selected in relation to the capacitance value of the other of said second and third capacitors so as to minimize parasitic phase shift and parasitic resonance effects on the feedback signal.
13. An oscillator as claimed in any preceding claim wherein said second impedance enables the setting of the gain of said amplifier independently of the capacitance of the second and third capacitors to provide improved power output flatness over the tuning range.
14. An oscillator as claimed in any preceding claim wherein said main capacitance includes a first varactor diode and a second varactor diode connected in series with one another, the cathodes of said varactor diodes being connected together and a DC return resistor being connected to the anode of said second varactor diode and to ground.
15. An oscillator as claimed in any of claims 1 to 13 wherein said main capacitance includes a first varactor diode and a second varactor diode connected in series with one another, the cathodes of the varactor diodes being connected together and the anode of the second varactor being connected to ground to increase the tuning range.
16. An oscillator as claimed in any preceding claim including a tuned series resonant circuit tuned and ganged to said resonant tank circuit, said tuned series resonant circuit being connected between said second impedance and said second and third capacitors.
17. An oscillator as claimed in any preceding claim including a capacitor connected across said first impedance to allow for the adjustment of the gain of said amplifier independently of the adjustment of said second impedance.
18. An oscillator as claimed in any preceding claim including a capacitor connected between said input and said one capacitor in said feedback loop.
19. An oscillator as claimed in any preceding claim wherein said inductor, said other of said second and third capacitors, an element connected to said second impedance and said first impedance, and a second element in the power output of said amplifier are transmission line sections to operate at high microwave frequencies.
20. An oscillator as claimed in any preceding claim including a power output terminal coupled through an AC output coupling and impedance matching means connected to a power output of said signal amplifier.
21. An oscillator as claimed in claim 20 wherein said coupling and matching means includes a capacitor connected between said amplifier and power output terminal, an inductor coupled to said capacitor and said amplifier power output, and a bypass capacitor connected between said inductor and ground to provide an RF ground.
22. An oscillator as claimed in any of claims 1 to 19 including a power output terminal coupled to said first impedance.
23. An oscillator as claimed in any of claims 1 to 19 including a power output terminal coupled to said inductor.
24. An oscillator as claimed in claim 23 including a coupling capacitor and an active device connected in an amplifier circuit coupled between said power output terminal and said inductor.

Revendications.



1. Oscillateur électronique à large bande comprenant :

un circuit bouchon comprenant des moyens à inductance (L1), une capacité principale (C1) et des second et troisième condensateurs (C3,C4) branchés en série pour produire des oscillations;

un amplificateur de signaux (A) pour compenser des pertes afin d'entretenir des oscillations dans le circuit bouchon, ledit amplificateur possédant une entrée et une sortie, ledit amplificateur amplifiant un signal dans un trajet de sortie de puissance et délivrant également un signal de réaction à sa sortie, lequel signal de réaction étant renvoyé à l'entrée de l'amplificateur par l'intermédiaire d'une partie du circuit bouchon, qui comprend l'un desdits second et troisième condensateurs (C3,C4);

une première impédance (R4) branchée entre ladite sortie et la masse;

une seconde impédance raccordée entre un point situé entre lesdits second et troisième condensateurs et ladite sortie;

caractérisé en ce que :

ladite seconde impédance comprend une réactance (C5) servant à maintenir le déphasage du signal de réaction entre l'entrée et la sortie dudit amplificateur (A) sensiblement à zéro degré et à réduire les composantes de bruit à proximité de la fréquence d'oscillation, ladite seconde impédance (C5) possédant une valeur élevée aux basses fréquences par rapport à la première impédance (R4) de sorte que les composantes de bruit à basses fréquences sont dissipées dans ladite première impédance (R4), ladite seconde impédance (C5) réduisant également la charge de ladite première impédance sur ledit circuit bouchon de manière à accroître le Q et à améliorer de ce fait la stabilité des oscillations dans ledit circuit bouchon.

2. Oscillateur selon la revendication 1, dans lequel ladite seconde impédance comprend une capacité (C5).

3. Oscillateur selon la revendication 1 ou 2, dans lequel ladite capacité principale comprend un condensateur d'accord.

4. Oscillateur selon la revendication 3, dans lequel ladite capacité principale comprend une diode varactor.

5. Oscillateur selon la revendication 4, comprenant une borne d'entrée d'accord de tension servant à envoyer une tension positive d'accord à une électrode formant cathode de ladite diode varactor par rapport à une électrode formant anode de ladite diode varactor.

6. Oscillateur selon l'une quelconque des revendications précédentes, dans lequel ledit amplificateur est un dispositif actif se présentant sous la forme d'un transistor possédant une base et un émetteur raccordés dans ladite boucle de réaction.

7. Oscillateur selon la revendication 6, dans lequel ladite base est couplée à ladite capacité principale et audit un desdits second et troisième condensateurs.

8. Oscillateur selon la revendication 6 ou 7, dans lequel ledit émetteur est raccordé à ladite première impédance.

9. Oscillateur selon l'une quelconque des revendications précédentes, dans lequel ladite première impédance est une résistance.

10. Oscillateur selon l'une quelconque des revendications précédentes, dans lequel la capacité desdits condensateurs dans ledit circuit bouchon, à l'exclusion de ladite capacité principale, est relativement élevée par rapport à la capacité de ladite capacité principale de sorte que la fréquence de résonance du circuit bouchon dépend essentiellement de la valeur de ladite capacité principale.

11. Oscillateur selon la revendication 10, dans lequel ladite gamme d'accord de la fréquence de résonance est supérieure au rapport 3:1.

12. Oscillateur selon l'une quelconque des revendications précédentes, dans lequel la valeur de ladite seconde impédance est choisie en rapport avec la valeur de la capacité de l'autre desdits second et



troisième condensateurs de manière à réduire le déphasage parasite et les effets de résonance parasites sur le signal de réaction.

- 5 13. Oscillateur selon l'une quelconque des revendications précédentes, dans lequel ladite seconde impédance permet le réglage du gain dudit amplificateur indépendamment de la capacité des second et troisième condensateurs de manière à obtenir une planéité améliorée de la puissance de sortie dans la gamme d'accord.
- 10 14. Oscillateur selon l'une quelconque des revendications précédentes, dans lequel ladite capacité principale comprend une première diode varactor et une seconde diode varactor branchées en série, les cathodes desdites diodes varactor étant raccordées entre elles, et une résistance de retour de courant continu étant raccordée à l'anode de ladite seconde diode varactor et à la masse.
- 15 15. Oscillateur selon l'une quelconque des revendications 1 à 13, dans lequel ladite capacité principale comprend une première diode varactor et une seconde diode varactor branchées en série, les cathodes des diodes varactor étant raccordées ensemble, et l'anode de la seconde diode varactor étant raccordée à la masse de manière à accroître la gamme d'accord.
- 20 16. Oscillateur selon l'une quelconque des revendications précédentes comprenant un circuit résonnant série accordé, qui est réglé et synchronisé sur ledit circuit bouchon, ledit circuit résonnant série accordé étant branché entre ladite seconde impédance et lesdits second et troisième condensateurs.
- 25 17. Oscillateur selon l'une quelconque des revendications précédentes, comprenant un condensateur branché aux bornes de ladite première impédance de manière à permettre le réglage du gain dudit amplificateur indépendamment du réglage de ladite seconde impédance.
- 30 18. Oscillateur selon l'une quelconque des revendications précédentes, comprenant un condensateur branché entre ladite entrée et ledit un condensateur dans ladite boucle de réaction.
- 35 19. Oscillateur selon l'une quelconque des revendications précédentes, dans lequel ladite inductance, ledit autre desdits second et troisième condensateurs, un élément raccordé à ladite seconde impédance et à ladite première impédance et un second élément dans la sortie de puissance dudit amplificateur sont des sections de lignes de transmission destinées à fonctionner à des hyperfréquences élevées.
- 40 20. Oscillateur selon l'une quelconque des revendications précédentes, comprenant une borne de sortie de puissance accouplée par l'intermédiaire de moyens de couplage et d'adaptation d'impédance de sortie à courant alternatif, raccordés à une sortie de puissance dudit amplificateur de signaux.
- 45 21. Oscillateur selon la revendication 20, dans lequel lesdits moyens de couplage et d'adaptation comprenant un condensateur branché entre ledit amplificateur et la borne de sortie de puissance, une inductance couplée audit condensateur et à ladite sortie de puissance de l'amplificateur, et un condensateur de dérivation branché entre ladite inductance et la masse de manière à fournir une masse pour les hautes fréquences.
- 50 22. Oscillateur selon l'une quelconque des revendications 1 à 19, comportant une borne de sortie de puissance couplée à ladite première impédance.
23. Oscillateur selon l'une quelconque des revendications 1 à 19, comportant une borne de sortie de puissance couplée à ladite inductance.
- 55 24. Oscillateur selon la revendication 23 comprenant un condensateur de couplage et un dispositif actif raccordés dans un circuit amplificateur branché entre ladite borne de sortie de puissance et ladite inductance.

55 Patentansprüche

1. Elektronischer Breitband-Oszillator, umfassend:
einen Resonanz-Abstimmungskreis mit einer Induktanz (L1), einer Hauptkapazität (C1) und einem



zweiten und dritten Kondensator (C3 und C4), hintereinandergeschaltet zur Schwingungserzeugung.

einen Signalverstärker (A) für den Verlustausgleich zur Aufrechterhaltung von Schwingungen in dem Abstimmungskreis, welcher Verstärker einen Eingang und einen Ausgang besitzt und ein Signal in einem Leistungsausgangspfad verstärkt und außerdem ein Rückkopplungssignal von seinem Ausgang abgibt, welches Rückkopplungssignal an den Eingang des Verstärkers über einen Teil des Abstimmungskreises zurückgeleitet wird, welcher Teil entweder den genannten ersten oder den genannten zweiten Kondensator (C3,C4) enthält,

eine erste Impedanz (R4), die zwischen dem genannten Ausgang und Erde liegt,

eine zweite Impedanz, die zwischen einen Punkt zwischen dem genannten zweiten und dem genannten dritten Kondensator und den genannten Ausgang geschaltet ist, dadurch gekennzeichnet,

daß die genannte zweite Impedanz eine Reaktanz (C5) enthält, um die Phasenverschiebung des Rückkopplungssignals zwischen dem Eingang und dem Ausgang des genannten Verstärkers (A) auf im wesentlichen 0° zu halten, und um Rauschanteile in der Nähe der Schwingfrequenz herabzusetzen, welche zweite Impedanz (C5) bei niedrigen Frequenzen einen hohen Wert im Vergleich zu der ersten Impedanz (R4) hat, so daß die niederfrequenten Rauschanteile in der genannten ersten Impedanz (R4) abgeleitet werden, welche genannte zweite Impedanz (C5) ferner die Belastung der genannten ersten Impedanz auf den genannten Abstimmungskreis herabsetzt, um den Gütefaktor zu erhöhen und dadurch die Stabilität der Schwingungen in dem genannten Abstimmungskreis zu

2. Oszillator nach Anspruch 1, worin die genannte zweite Impedanz eine Kapazität (C5) umfaßt.
3. Oszillator nach Anspruch 1 oder 2, worin die genannte Hauptkapazität einen Abstimmkondensator umfaßt.
4. Oszillator nach Anspruch 3, worin die genannte Hauptkapazität eine Varaktordiode umfaßt.
5. Oszillator nach Anspruch 4, umfassend eine Spannungsabstimmeingangsklemme zum Zuführen einer positiven Abstimmspannung auf eine Kathodenelektrode der genannten Varaktordiode, bezogen auf eine Anodenelektrode der genannten Varaktordiode.
6. Oszillator nach einem der vorhergehenden Ansprüche, worin der genannte Verstärker eine aktive Vorrichtung in Form eines Transistors ist, dessen Basis und Emitter in der genannten Rückkopplungsschleife liegen.
7. Oszillator nach Anspruch 6, worin die genannte Basis mit der genannten Hauptkapazität und mit dem genannten einen Kondensator der genannten zweiten und dritten Kondensatoren verbunden ist.
8. Oszillator nach Anspruch 6 oder 7, worin der genannte Emitter mit der genannten ersten Impedanz verbunden ist.
9. Oszillator nach einem der vorhergehenden Ansprüche, worin die genannte erste Impedanz ein Widerstand ist.
10. Oszillator nach einem der vorhergehenden Ansprüche, worin die Kapazität der genannten Kondensatoren in dem genannten Resonanz-Abstimmungskreis, ausgenommen die genannte Hauptkapazität, verhältnismäßig groß im Vergleich zu der Kapazität der genannten Hauptkapazität ist, so daß die Resonanzfrequenz des Abstimmungskreises in erster Linie von dem Wert der genannten Hauptkapazität abhängt.
11. Oszillator nach Anspruch 10, worin der genannte Resonanzfrequenzabstimbereich ein Verhältnis von mehr als 3:1 hat.
12. Oszillator nach einem der vorhergehenden Ansprüche, worin der Wert der genannten zweiten Impedanz im Vergleich zu dem Kapazitätswert des anderen Kondensators der genannten beiden zweiten und dritten Kondensatoren so gewählt ist, daß die Wirkungen von störender Phasenverschiebung und störender Resonanz auf des Rückkopplungssignal so gering wie möglich bleiben.
13. Oszillator nach einem der vorhergehenden Ansprüche, worin die genannte zweite Impedanz das



Einstellen des Gewinns des genannten Verstärkers unabhängig von der Kapazität des zweiten und dritten Kondensators ermöglicht, um über den Abstimbereich eine verbesserte Ebenheit des Leistungsausgangs zu erzielen.

- 5 14. Oszillator nach einem der vorhergehenden Ansprüche, worin die genannte Hauptkapazität eine erste Varaktordiode und eine zweite Varaktordiode umfaßt, die hintereinandergeschaltet sind, wobei die Kathoden der genannten Varakterdioden miteinander verbunden sind und ein Gleichstrom-Rückleistungs-widerstand an die Anode der genannten zweiten Varaktordiode und an Erde gelegt ist.
- 10 15. Oszillator nach einem der Ansprüche 1 bis 13, worin die genannte Hauptkapazität eine erste Varaktordiode und eine zweite Varakterdiode umfaßt, die hintereinandergeschaltet sind, wobei die Kathoden der Varakterdioden miteinander verbunden sind und die Anode der zweiten Varakterdiode an Erde gelegt ist, um den Abstimbereich zu erweitern.
- 15 16. Oszillator nach einem der vorhergehenden Ansprüche, umfassend einen abgestimmten Reihenresonanzkreis, abgestimmt und gekuppelt mit dem genannten Resonanz-Abstimmungskreis, welcher abgestimmte Reihenresonanzkreis zwischen die genannte zweite Impedanz und die genannten zweiten und dritten Kondensatoren geschaltet ist.
- 20 17. Oszillator nach einem der vorhergehenden Ansprüche, umfassend einen zu der genannten ersten Impedanz parallel geschalteten Kondensator, um den Gewinn des genannten Verstärkers unabhängig von der Einstellung der genannten zweiten Impedanz einstellen zu können.
- 25 18. Oszillator nach einem der vorhergehenden Ansprüche, umfassend einen Kondensator, der zwischen den genannten Eingang und den genannten einen Kondensator in der genannten Rückkopplungsschleife geschaltet ist.
- 30 19. Oszillator nach einem der vorhergehenden Ansprüche, worin die genannte Induktivität, der andere der beiden zweiten und dritten Kondensatoren, ein mit der genannten zweiten Impedanz und der genannten ersten Impedanz verbundenes Element und ein zweites Element in dem Leistungsausgang des genannten Verstärkers Übertragungsleitungsabschnitte sind, die mit hohen Mikrowellenfrequenzen arbeiten.
- 35 20. Oszillator nach einem der vorhergehenden Ansprüche, umfassend eine Leistungsausgangsklemme, gekoppelt über eine Wechselstrom-Auskopplungs- und Impedanzanpassungseinrichtung die mit einem Leistungsausgang des genannten Signalverstärkers verbunden ist.
- 40 21. Oszillator nach Anspruch 20, worin die genannte Kopplungs- und Anpassungseinrichtung einen Kondensator umfaßt, der zwischen den genannten Verstärker und die genannte Leistungsausgangsklemme geschaltet ist, eine Induktivität, die an den genannten Kondensator und den genannten Verstärkerleistungsausgang gekoppelt ist, und einen Ableitkondensator, der zwischen die genannte Induktivität und Erde geschaltet ist, um eine HF-Erdung herzustellen.
- 45 22. Oszillator nach einem der Ansprüche 1 bis 18, mit einer an die genannte erste Impedanz angeschlossenen Leistungsausgangsklemme.
23. Oszillator nach einem der Ansprüche 1 bis 19, mit einer an die genannte Induktivität angeschlossenen Leistungsausgangsklemme.
- 50 24. Oszillator nach Anspruch 23, mit einem Kopplungskondensator und einer aktiven Vorrichtung, geschaltet in einen Verstärkerkreis, der zwischen die genannte Leistungsausgangsklemme und die genannte Induktivität geschaltet ist.