

# PATENT SPECIFICATION

1,072,780

DRAWINGS ATTACHED.

1,072,780



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## COMPLETE SPECIFICATION.

### UHF Oscillator Circuits.

We, RADIO CORPORATION OF AMERICA, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to ultra high frequency (UHF) oscillator circuits, and has for its object to improve the tuning of circuits of this type.

Accordingly the present invention provides a tunable ultra high frequency oscillator circuit comprising a transistor connected to provide oscillations; a frequency determining network including a tunable transmission line having first and second transmission line conductors; a variable tuning capacitor coupled at one end of said tunable transmission line for adjusting the frequency of resonance of said transmission line; a low inductance capacitor coupled at the other end of said tunable transmission line to determine the minimum frequency of operation of said oscillator circuit; and circuit means for coupling sufficient energy between said tunable transmission line and said transistor to sustain oscillations.

The invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic schematic circuit diagram of a UHF oscillator circuit in accordance with an embodiment of the invention;

Figure 2 is a graph illustrating the frequency drift of the oscillator circuit shown in Figure 1 as a function of the magnitude of the coupling capacitor, for a  $\pm 10\%$

change in the operating voltage at a frequency of oscillation of 600 megacycles per second;

Figure 3 is a graph illustrating the frequency drift of the oscillator circuit shown in Figure 1 as a function of the frequency of oscillation for a  $\pm 10\%$  change in the operation voltage;

Figure 4 is a diagrammatic schematic circuit diagram of a portion of a UHF tuner for a super-heterodyne receiver including separate oscillator and mixer circuits according to an embodiment of the invention;

Figure 5 is a graph illustrating the frequency drift of the oscillator circuit shown in Figure 4, as a function of the frequency of oscillation for a  $\pm 10\%$  change in the operating voltage; and

Figure 6 is a graph illustrating the conditions for oscillation of the circuit shown in Figure 4 including the reflected admittance characteristic of the resonant circuit as a function of frequency, the susceptance characteristic of the output capacitance of the transistor as a function of frequency, and the transconductance characteristic of the transistor as a function of frequency.

Reference is now made to Figure 1 which is a diagrammatic schematic circuit diagram of a UHF oscillator circuit in accordance with an embodiment of the invention which may be included in a UHF tuner which may be used in a super-heterodyne receiver. The UHF oscillator circuit shown in Figure 1 may be an oscillator circuit whose operation extends throughout the UHF television band (470 to 890 megacycles). The oscillator circuit includes a transistor 10 which is connected as the active element of the oscillator circuit. The base electrode 12 is coupled to a source of operating potential (not shown) through a resistor 14. The resistor

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14 forms with the resistor 16 a voltage divider network that biases the base electrode 12 to a desired potential with respect to the potential in the emitter electrode 18.

5 The emitter electrode 18 is connected through a resistor 20 to a point of fixed reference potential provided in this case by a conductive chassis 22 which forms the local oscillator compartment. The resistor 10 16 is also connected to the chassis 22.

The collector electrode 24 of the transistor 10 is connected to the source of operating potential previously mentioned, through a parallel circuit which includes an inductor 15 28 and a resistor 26. The inductor 28 is a radio frequency choke which provides a large alternating current (a—c) impedance and a small direct current (d—c) resistance to the collector circuit of the transistor 10. 20 The large a—c impedance permits the oscillation to have the desired amplitude. However, the inductance of the inductor 28 in conjunction with the intrinsic capacitance of the transistor 10 and with the intrinsic 25 capacitance of the circuit resonates at a frequency other than the desired frequency of operation. The spurious oscillation caused by the inductance of the inductor 28, however, is damped by the resistor 26, which has a small value of resistance. A 30 feed-through capacitor 30 provides a low impedance path for signals at the oscillator frequency. The base electrode 12 is bypassed at signal frequencies by means of a 35 feedthrough capacitor 32, connected between the base electrode 12 and the voltage divider network, to provide a common base oscillator circuit. The desired bias voltage is applied to the base electrode 12 40 by means of the center conductor of the feedthrough capacitor 32.

The frequency of operation of the oscillator circuit is determined by a transmission line comprising an inner conductor 36 and 45 an outer conductor formed by the conductive chassis 22. A variable tuning capacitor 38 is connected between one end of the transmission line conductor 36 and the conductive chassis 22.

50 The capacitor 38 may be, for example as shown, a parallel plate type tuning capacitor having fixed stator plates 23 and rotatable rotor plates 25. The set of stator plates 23 forms an integrated part with the transmission line conductor 36. The shaft 55 42 which is connected to the conductive chassis 22 supports the rotor plates 25 of the capacitor 38, and is rotatable to change the relative positions of the rotor plates 25 with respect to the stator plates and thereby 60 vary the capacitance of the capacitor 38.

The collector electrode 24 is coupled to the other end of the transmission line conductor 36 through a capacitor 44 which may 65 be a disc type capacitor and which has a

small value of capacitance, such as two picofarads for example, to provide coupling between the transistor and the frequency determining network. The coupling provided by the capacitor 44 between the trans- 70 mission line and the collector electrode circuit of the transistor 10 is such that the output impedance of the transistor 10 is loosely coupled to the frequency determining network, (the coupling capacitor 44 presents a high reactance at signal frequencies), 75 so that changes in the output impedance of the transistor cause a relatively small effect on the frequency determining network of the oscillator circuit whereby the frequency drift 80 of the oscillator is minimized.

A trimmer capacitor 46 is connected between said other end of the transmission line conductor 36 and the chassis 22. The capacitor 46 is utilized to adjust the lower 85 frequency end of the oscillator's frequency band of operation to the minimum frequency desired. The capacitor 46 includes a stator electrode with an extension plate 48 extending parallel to the chassis 22 to provide a 90 low inductance capacitance. The total inductance of the capacitor 46 and extension plate 48 is small enough that the frequency of resonance of the path extending from the collector electrode 24 to the chassis 95 through the coupling capacitor 44 and the trimmer capacitor 46 is well above the cut-off frequency of the transistor. If the trimmer capacitor 44 exhibits substantial inductance, it has been found that the coupling 100 capacitor 44 may resonate with this inductance at a frequency below the cut-off frequency of the transistor, and lock the oscillator to a frequency determined by these 105 elements so that variations of the tuning capacitor then do not materially effect the frequency of operation of the circuit.

Reference is now made to Figure 2, which is a graph showing the frequency deviation in kilocycles per second as a function 110 of the magnitude of the coupling capacitor 44 in micro-microfarads for a  $\pm 10\%$  change in the operating voltage; the frequency of operation of the oscillator circuit being equal to 600 megacycles per 115 second.

The curve A represents a 10% increase in the operating voltage, and the curve B represents a 10% decrease in the operating voltage. As indicated by Figure 2, curves 120 A and B are substantially symmetrical. Also, as indicated in Figure 2, the frequency deviation of the oscillator circuit increases as the magnitude of the coupling capacitor 44 increases. At a value of the coupling capacitor 44 of approximately two picofarads, 125 the frequency change, for a change in operating voltage of  $\pm 10\%$ , is approximately 60 KC. At a value of the coupling capacitor 44 equal to eight picofarads a voltage change 130

of  $\pm 10\%$  produces a frequency change of 160 KC. When the value of the coupling capacitor 44 is equal to sixteen picofarads, the frequency change is approximately 400 KC.

Reference is now made to Figure 3 which is a graph illustrating the frequency drift of the oscillator circuit shown in Figure 1, as a function of the frequency of oscillation, for  $\pm 10\%$  change in the operating voltage. The coupling capacitor 44 employed had a value of two micro-microfarads. The curve *I* represents a 10% increase in the operating voltage, and the curve *J* represents a 10% decrease in the operating voltage. As shown in Figure 3, curves *I* and *J* are substantially symmetrical, and the frequency deviation (50 kilocycles) is a minimum at a frequency equal to approximately 800 megacycles per second. At around 500 megacycles and 900 megacycles the frequency deviation is about 100 kilocycles per second and this represents the maximum frequency drift of the oscillator circuit operable throughout the UHF television band.

The oscillator circuit shown in Figure 4 utilizes inductive coupling in such a manner as to provide the same advantages as those described in connection with the circuit shown in Figure 1. A transistor 50 is connected as the active element of the oscillator circuit. The base electrode 56 is bypassed at signal frequencies by the feedthrough capacitor 52 to provide a common base oscillator type circuit. A source of operating potential (not shown) is applied to the terminal 54. The base electrode 56 is biased to a desired potential by means of a voltage divider network comprising resistors 58 and 60 connected in series between the terminal 54 and the conductive chassis 62, which forms the oscillator compartment. The center conductor of the capacitor 52 applies the desired bias voltage from the voltage divider network to the base electrode 56 of the transistor 50.

The emitter electrode 62 is connected through a resistor 64 to the terminal 54, which is bypassed at signal frequencies by the feedthrough capacitor 66. The collector electrode 68 is connected to the chassis 69 through a coupling link 72. The frequency determining network of the oscillator circuit includes a coaxial transmission line, i.e. inner and outer conductors, comprising a transmission line conductor 74 and the conductive chassis 69, respectively.

A capacitor 80 is a variable tuning capacitor which may be similar to the variable capacitor 38 described in connection with Figure 1. The capacitor 78 is a trimmer capacitor similar to the capacitor 46 described in connection with the circuit shown in Figure 1. In addition, the required low inductance capacitance to determine the

minimum frequency of operation is provided by an extension plate 79 which may be similar to the low inductance capacitor 46, shown in Figure 1.

The collector circuit of the transistor 50 is inductively coupled to the transmission line by the coupling link 72 previously described. By inductively coupling the oscillator's tank circuit to the collector circuit loose coupling of the frequency determining network and the transistor 50 is effected. As previously described, the frequency drift of the oscillator circuit due to changes in the transistor parameters (due to changes in the source of operating potential and ambient temperature) is minimized by loose coupling. The frequency deviation in kilocycles as a function of  $\pm 10\%$  change in operating voltage throughout the UHF television band of operation of the oscillator circuit of Figure 4 is shown in Figure 5.

In Figure 5, curve *D* represents a 10% increase in the operating voltage, and curve *E* represents a 10% decrease in the operating voltage. As shown in Figure 5, curves *D* and *E* are substantially symmetrical, and the frequency deviation increases as a function of the operating frequency; the deviation being a maximum at the maximum operating frequency. If the oscillator circuit is employed as a UHF oscillator tunable over the UHF television band, the maximum frequency deviation at 890 MC is approximately 200 KC.

Figure 6 illustrates the required conditions for oscillation. The curve *F* illustrates the susceptance characteristic seen by the transistor circuit as a function of frequency, the curve *G* represents the negative of the susceptance characteristic of the output capacitance of the transistor circuit, and the curve *H* represents the transconductance ( $g_m$ ) characteristic of the transistor 50. The condition for oscillation is that the total susceptance of the circuit must equal zero. The points of zero susceptance, the intersections of curves *F* and *G* occur at the frequencies  $f_1$  and  $f_2$ . The oscillator circuit, however, will oscillate only at the frequency  $f_1$  because as illustrated by the curve *H*, the necessary value of transconductance to sustain oscillations is a minimum at  $f_{max}$ . At frequencies higher than  $f_{max}$  the value of  $g_m$  is too small to sustain oscillations.

The output energy from the oscillator circuit of Figure 4 may be coupled from the oscillator's tank circuit to a mixer circuit, for example, by means of a coupling link 82 connected between the cathode electrode 84, of the diode 86, and ground (the wall 69 of the oscillator compartment). The anode electrode 88 is connected to a series circuit including a capacitor 90 and an inductor 92. The capacitor 90 is connected between the wall 69 and the anode electrode

88. Intermediate frequency signals are derived from the diode 86 through the inductor 92. The capacitor 90 and the inductor 92 form a low pass filter to attenuate signal frequencies.

One of the advantages obtained with the circuit shown in Figure 4 is that the power output provided by the circuit is substantially constant. Because the coupling between the transistor and the frequency determining network increases as the frequency of operation is increased simultaneously with a decrease of transconductance of the transistor also as a function of frequency, the constant power output characteristic of the circuit is obtained.

The increase in signal coupling as a function of frequency, i.e., more energy is coupled at higher frequencies, is effected because the self resonating frequency of the transistor output capacitance and the loop coupling, (approximately 1500 MC) is fixed at a frequency higher than the maximum frequency of operation (approximately 1000 MC). Therefore as the operating frequency is increased, the frequency of resonance of both the transistor circuit and the frequency determining network are closer to each other, which results in a higher signal coupling.

#### WHAT WE CLAIM IS:—

1. A tunable ultra high frequency oscillator circuit comprising a transistor connected to provide oscillations; a frequency determining network including a tunable transmission line having first and second transmission line conductors; a variable tuning capacitor coupled at one end of said tunable transmission line for adjusting the frequency of resonance of said transmission line; a low inductance capacitor coupled at the other end of said tunable transmission line to determine the minimum frequency of operation of said oscillator circuit; and circuit means for coupling sufficient energy between said tunable transmission line and said transistor to sustain oscillations.

2. A tunable ultra high frequency oscillator circuit according to Claim 1, wherein said second transmission line conductor is a conductive chassis which supports said first transmission line conductor, and said low inductance capacitor has a conductive

member extending in capacitive relation to said chassis so as to provide low inductance capacitance coupling between said first transmission line conductor and said chassis.

3. A tunable ultra high frequency oscillator circuit according to Claim 2, wherein said first transmission line conductor has an end portion spaced closer to a wall of said conductive chassis than its main body portion, said low inductance capacitor is coupled between said end portion of said first transmission line conductor and said chassis and exhibits sufficiently low inductance in combination with said end portion of said first transmission line conductor so that the frequency of resonance of the circuit loop including said transistor, said circuit coupling means, and said minimum frequency determining capacitor, is above the cutoff frequency of said transistor.

4. A tunable ultra high frequency oscillator circuit according to Claim 2 or Claim 3, wherein said circuit means comprises inductive circuit means including a coupling link connected between said transistor and said chassis.

5. A tunable ultra high frequency oscillator circuit according to any one of Claims 1 to 3, wherein said circuit means comprises capacitive circuit means coupled between said tunable transmission line and said transistor and exhibiting relatively large capacitive reactance at ultra high frequencies for coupling substantially the minimum necessary energy to sustain oscillations of predetermined strength over the range of frequencies to be tuned by said oscillator.

6. A tunable ultra high frequency oscillator circuit according to Claim 5, wherein said capacitive circuit means includes a capacitor having a capacity of two micro-microfarads.

7. A tunable ultra high frequency oscillator circuit substantially as herein described and as illustrated with reference to Figure 1 of the accompanying drawings.

8. A tunable ultra high frequency oscillator circuit substantially as hereinbefore described and as illustrated with reference to Figure 4 of the accompanying drawings.

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2. A tunable ultra high frequency oscillator circuit according to Claim 1, wherein said second transmission line conductor is a conductive chassis which supports said first transmission line conductor, and said low inductance capacitor has a conductive

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