

1 FREQUENCY SELECTIVE NETWORK

 The present invention relates to the field of
frequency selective netowrks. An illustrative example of such a
network is for discriminating against image response in a super-
5 heterodyne receiver, such as a typical television receiver and
reference is made to that example hereinafter.

 Aspects of the invention are specified in the claims.

 In superheterodyne receivers, there is a possibility of obtain-
ing a variety of spurious responses. Image frequency signals are a
10 principal source of spurious responses. Image signals are signals
having a frequency that is greater than the frequency to which the
receiver is tuned by twice the intermediate frequency (IF),

 In superheterodyne receivers, there is a
possibility of obtaining a variety of spurious responses.
15 Image frequency signals are a principal source of spurious
responses. Image signals are signals having a frequency
that is greater than the frequency to which the receiver
is tuned by twice the intermediate frequency (IF),
assuming the local oscillator operates at a higher
20 frequency than the desired signal. If such signals reach
the mixer, they combine with the local oscillator
frequency to produce a difference frequency that is
exactly equal to the IF, and so appear in the receiver
output along with the desired signal. Interference by
25 image frequency signals is particularly undesirable in a
television receiver, since interference with the displayed
image is readily perceived and is generally annoying to
the viewer.

 Image responses can be reduced by providing
30 sufficient selectivity between the receiver input and the
mixer source to prevent a signal of image frequency from
reaching the mixer with appreciable amplitude. Special
coupling circuits have been used in radio receivers for
improving discrimination against image signals without
35 significantly attenuating the desired signal. Such
coupling circuits should also provide tracking of the

1 image suppression or trap frequency with tuning variation
such that the frequency separation between the tuning
frequency and the trap frequency remains constant. This
requirement results from the fact that the image frequency
5 separation from the desired signal frequency is
independent of tuning, being equal to twice the IF.
Examples of such coupling circuits are described in "Radio

10

15

20

25

30

35

Receiver Design" by K.R. Sturley, published by Chapman & Hall, Ltd., London; 1953, pp 349-353, and in "Radio Engineers' Handbook" by F.E. Terman, published by McGraw-Hill Book Company, Inc., New York; 1943, p. 645.

- 5 In these circuits, a neutralizing voltage is developed in an auxiliary coil coupled to the input. The circuit characteristics are selected so that the neutralizing voltage provides cancellation of image frequency signals but does not appreciably affect the desired signal.
- 10 However, the auxiliary coil in these examples is inductively coupled to other coils in the coupling circuit. While such arrangements using inductive coupling may be satisfactory at relatively low radio frequencies, their implementation poses problems at higher television
- 15 frequencies, particularly at ultra high frequencies (UHF). At such frequencies, the inductances may consist merely of a short strip of copper foil and under such conditions, the problems of obtaining and adjusting inductive coupling are very difficult and are undesirable, particularly in
- 20 mass production.

In accordance with an embodiment of the invention a first parallel resonant circuit is coupled to receive the input signal to the receiver and is further mutually coupled to a second parallel resonant circuit by a first

25 coupling. A circuit impedance is coupled in the capacitive branch of the first resonant circuit for providing a neutralizing signal. At least a portion of the neutralizing signal is coupled into the inductive branch of the second resonant circuit by a second

30 coupling.

In accordance with another embodiment of the invention, both resonant circuits are tuned to the desired signal frequency.

In accordance with a further embodiment of the

35 invention, the circuit impedance is selected to exhibit a frequency characteristic such that substantial cancellation occurs in the inductive branch of the second resonant circuit between image frequency signal components

coupled by way of the first coupling and image frequency components coupled by way of the second coupling. In accordance with yet another embodiment of the invention, cancellation of corresponding desired signal frequency components is substantially less than the cancellation between image frequency components. In accordance with still another embodiment of the invention, the frequency separation between the desired signal and image frequencies is substantially constant.

The invention will be explained by way of example with reference to the accompanying drawings in which

FIGURE 1 shows partly in block form and partly in circuit diagram form a schematic of an RF coupling arrangement including a preferred embodiment of the present invention; and

FIGURE 2 shows partly in block form and partly in circuit diagram form a schematic of an implementation of the coupling arrangement shown in FIGURE 1.

In the coupling arrangement of FIGURE 1, a radio frequency (RF) source 100 is coupled to a tuned circuit 102 which comprises a tuning capacitance 104 and an inductance 106 which together form a parallel resonant circuit. The resonant circuit is completed by inductance 106 being connected to a common ground 108 and by capacitance 104 being coupled to ground by way of a resonant circuit 110 which comprises a parallel combination of a capacitance 112 and an inductance 114. Current in capacitance 104 will therefore cause a voltage to appear across the circuit impedance of resonant circuit 110. Resonant circuit 102 is tuned to the desired signal frequency supplied by RF source 100. RF source 100 may, for example, include an RF amplifier coupled to a signal source such as a receiving antenna or cable television outlet. While resonant circuit 102 will exhibit maximum response at the desired signal frequency, it will also exhibit some response at other frequencies such as the image frequency. Thus, signals at the desired signal

frequency and signals at the image frequency which may be present in the output of RF source 100 will cause corresponding voltages to appear across resonant circuit 110.

5 A further resonant circuit 116 comprises an inductance 118 and a capacitance 120 which together form a parallel resonant circuit, which is also tuned to the desired signal frequency. Capacitance 120 is coupled to ground, whereas inductance 118 is coupled to ground by way
10 of a coupling 115 through resonant circuit 110, i.e., resonant circuit 110 forms a common impedance in the coupling to ground of both capacitance 104 and inductance 118. The voltage developed across tuned circuit 110 by the current in capacitance 104 will therefore be injected
15 into resonant circuit 116. Resonant circuits 102 and 116 are also mutually coupled by a coupling 122, shown in FIGURE 1 in block form. Coupling 122 may be implemented in any convenient and suitable form, an example of which will be described later. As is well known from circuit
20 theory, such couplings can generally be reduced to an equivalent simple coupled circuit with mutual inductance coupling. Signals coupled to inductance 118 by way of coupling 122 will be in addition to signals coupled to inductance 118 by way of resonant circuit 110. There will
25 therefore be two signal components in inductance 118 for each signal frequency present in the output of RF source 100. It has been found possible to cause these components to cancel each other substantially for signals at the image frequency without appreciably affecting signals at
30 the desired signal frequency. This is achieved by appropriately choosing the circuit element values and the sign of coupling 122 so that the image frequency components coupled to inductance 118 are of equal amplitude and opposite sign. Due to the frequency
35 dependent characteristics of the couplings, these conditions are not met at the desired signal frequency and significant cancellation does not occur. The coupling arrangement therefore functions as a trap for image frequency signals and the output from resonant

circuit 116 will exhibit a relatively smaller image signal compared with the output of RF source 100. The output derived from resonant circuit 116 is then applied to receiver signal processing circuits 122 for further processing.

As previously mentioned, it is desirable for the separation between the tuning frequency and the image trap frequency to remain constant with tuning. The operation of resonant circuit 110 in substantially achieving this requirement can be explained as follows. If it first be assumed that capacitance 112 is not connected, it can be shown that the frequency separation between the tuning frequency and the trap frequency is proportional to the tuning frequency, with the proportionality being determined by inductance 114. A condition for the frequency separation not to vary when the tuning is varied is that the effective inductance of inductance 114 must vary inversely with the square of frequency over the frequency range of interest. While such a frequency-dependent inductance is fictitious, an equivalent effect is achieved in the present invention by the addition of capacitance 112 to form resonant circuit 110. With suitable values for capacitance 112 and inductance 114, it has been found that resonant circuit 110 can be made to exhibit an effective impedance corresponding to the impedance of a fictitious inductance whose effective value varies inversely with the square of frequency over the frequency range of interest. As has been explained, such a characteristic results in the separation between the image trap frequency and the tuning frequency remaining constant and therefore capable of tracking the actual image frequency as the tuning is varied.

FIGURE 2 shows an implementation of the coupling arrangement suitable for use in a television receiver, for example. A UHF signal source 200, which may, for example, comprise an antenna, a cable television outlet, or a video tape recorder, is coupled to an RF amplifier and tuning

circuits 201. Typically, the output of RF amplifier 201 will contain signals at the image frequency in addition to the desired signal. This output is applied to a resonant circuit 202 tuned to the desired signal frequency and comprising an inductance 206 and a capacitance 204 which will typically comprise a voltage controlled variable capacitance diode, as here schematically indicated. A grounded loop 207 is provided adjacent inductance 206 to permit trimming adjustments by bending the loop to change its coupling to inductance 206. Capacitance 204 is coupled to ground by way of a DC blocking capacitor 205 and an inductance 214 which typically is of such a small value that it can be implemented by a small section of conductive foil on a printed circuit board. Inductance 214 and a capacitance 212 form a resonant circuit 210 for providing a neutralizing voltage, corresponding to resonant circuit 110 in FIGURE 1. Capacitance 212 is typically very small and may usually be provided by stray capacitance associated with a conductor formed on a printed circuit board, so that no other capacitance component is needed.

The voltage developed across resonant circuit 210 is coupled to an inductance 218 by way of a voltage divider which comprises a series inductance 215 and a shunt inductance 219, both of which inductances may typically be formed by conductive strips on a printed circuit board. Thus, only a portion of the neutralizing voltage across resonant circuit 210 is actually coupled to inductance 218. A grounded loop 217 adjacent inductance 218 is provided for trimming adjustment. Inductance 218 forms a resonant circuit 216 at the desired signal frequency with a capacitance 220, shown as a variable capacitance diode, which is grounded by way of a DC blocking capacitor 221. Both capacitances 204 and 220 are supplied with a tuning voltage by way of resistors 203 and 225, respectively from a tuning voltage source 226, which also supplies a tuning voltage to tuning elements in RF amplifier 201.

Resonant circuits 202 and 216 are mutually coupled by a coupling 222 which comprises an inductance 223 and a capacitance 225 coupled in parallel. The output taken from resonant circuit 216 is applied to receiver
5 signal processing circuits 224 for further processing.

As will be understood from the correspondence of the FIGURE 1 and FIGURE 2 embodiments, the operation of the FIGURE 2 embodiment will substantially conform to the description already provided for the FIGURE 1 embodiment.
10 It is pointed out that the voltage divider comprising inductance 215 and 219 is employed because the signal amplitude required for image cancellation in inductance 218 is smaller than can be developed across inductance 214 when this is made in conveniently practical dimensions.

15 The implementation of the invention in accordance with FIGURES 1 and 2 is illustrative. Various modifications to the circuitry for implementing the invention in accordance with the foregoing description will be apparent. For example, other equivalent forms of
20 coupling may be used in place of the illustrative parallel resonant circuit 222. For another example, while tuning voltage source 226 is shown as supplying the same tuning voltage to tuning diodes 204 and 220 and to RF amplifier and tuning circuits 201, different voltages could be
25 supplied to those elements if required. Furthermore, the voltage divider comprising inductance 215 and 219 need not be used if the values of inductance 214 and capacitance 212 are correspondingly changed. In addition, while the operation of the invention has been described with
30 reference to radio frequency receivers, the invention may also be used in other applications where a trap frequency is required to track with tuning to a desired signal frequency.

1 CLAIMS:

1. In a superheterodyne radio frequency (RF) receiver having an RF signal input port and exhibiting an undesired image frequency response when tuned to a desired
5 signal frequency, an RF coupling arrangement comprising:
first and second resonant circuit means each comprising respective parallel-connected capacitive and inductive branches, said first resonant circuit means being coupled to said input port for receiving a signal at
10 said input port;
first coupling means for mutually coupling said first and second resonant circuit means;
impedance means coupled in series with said capacitive branch of said first resonant circuit means for
15 providing a neutralizing signal; and
second coupling means for coupling at least a portion of said neutralizing signal into said inductive branch of said second resonant circuit means.
- 20 2. The RF coupling arrangement recited in Claim 1 wherein said first and second resonant circuit means are resonant substantially at said desired signal frequency.
3. The RF coupling arrangement recited in Claim
25 2 wherein said impedance means is selected to exhibit a frequency characteristic such that substantial cancellation occurs over a predetermined range of said image frequency in said inductive branch of said second resonant circuit means between image frequency components
30 of a signal coupled by way of said first coupling means and image frequency components of said portion of said neutralizing signal.



1 4. The RF coupling arrangement recited in
claim 3 wherein cancellation in said inductive branch of
said second resonant circuit means of desired signal
frequency components of a signal coupled by way of said
5 first coupling means and desired signal frequency
components of said portion of said neutralizing signal is
substantially less than said cancellation between said
image frequency components.

10 5. The RF coupling arrangement recited in
claim 3 or 4 wherein the frequency difference between
said image frequency and said desired signal frequency
is substantially independent of said desired signal
frequency over a predetermined range of frequency.

15 6. The RF coupling arrangement recited in
claim 3, 4 or 5 wherein the frequency separation between
said desired signal frequency and said image frequency
is substantially constant.

20 7. The RF coupling arrangement recited in
claim 5 or 6 wherein said image frequency is higher than
said desired signal frequency.

25 8. The RF coupling arrangement recited in
claim 2, 3, 4, 5, 6 or 7 wherein said impedance means
comprises a third resonant circuit for providing said
neutralizing signal thereacross.

30 9. The RF coupling arrangement recited in
Claim 8, wherein said third resonant circuit comprises a
parallel connection of an inductance and a capacitance.

35 10. The RF coupling arrangement recited in
claim 8 or 9 wherein said coupling means comprises a
connection between said third resonant circuit and said
inductive branch of said second resonant circuit means.





- 1 11. The RF coupling arrangement recited in
claim 8, 9 or 10 when appended to claim 3 wherein the
resonant frequency of said third resonant circuit is
selected for causing the said substantial cancellation
5 over the said predetermined range of frequencies.
12. The RF coupling arrangement recited in any
preceding claim wherein said second coupling means
comprises a voltage divider.
- 10 13. The RF coupling arrangement recited in
claim 2 wherein said impedance means is selected to
exhibit a frequency characteristic such that substantial
cancellation occurs in said inductive branch of said
15 second resonant circuit means between components of said
portion of said neutralizing signal having a frequency
substantially equal to a predetermined trap frequency
and trap frequency components of a signal coupled by way
of said first coupling means.
- 20 14. The RF coupling arrangement recited in
claim 13 wherein cancellation in said inductive branch
of said second resonant circuit means of desired signal
frequency components of said portion of said
25 neutralizing signal and desired frequency components of
a signal coupled by way of said first coupling means is
substantially less than said cancellation between said
trap frequency components.
- 30 15. The RF coupling arrangement recited in
claim 13 or 14 wherein the frequency separation between
said trap frequency and said desired signal frequency is
substantially constant.
- 35 16. The RF coupling arrangement recited in
claim 15 wherein said trap frequency is substantially
equal to said image frequency.
17. A frequency selective circuit arrangement
comprising an input port for receiving a signal;

1 first and second resonant circuit means each
comprising respective parallel-connected capacitive and
inductive branches, said first resonant circuit means
being coupled to said input port for receiving a signal
5 at said input port;

first coupling means for mutually coupling
said first and second resonant circuit means;

impedance means coupled in series with said
capacitive branch of said first resonant circuit means
10 for providing a neutralizing signal; and

second coupling means for coupling at least a
portion of said neutralizing signal into said inductive
branch of said second resonant circuit means.

15 18. An arrangement according to claim 17
wherein said impedance means is selected to
exhibit a frequency characteristic such that substantial
cancellation occurs in said inductive branch of said
second resonant circuit means between components of said
20 portion of said neutralizing signal having a frequency
substantially equal to a predetermined trap frequency
and trap frequency components of a signal coupled by way
of said first coupling means.

25 19. A frequency selective circuit arrangement
substantially as hereinbefore described with reference
to Figure 1 optionally as modified by Figure 2.

30 20. A superheterodyne RF receiver including an
arrangement according to claim 19.

21. A receiver of television signals according
to claim 20.

35

