



WIDE FREQUENCY SPECTRUM TELEVISION TUNER WITH SINGLE LOCAL OSCILLATOR

5 FIELD OF THE INVENTION

The present invention concerns a television receiver having a conversion tuner for producing an intermediate frequency signal from an RF source signal.

10 BACKGROUND

It is a common practice to use more than one local oscillator to tune the full frequency range of television RF sources, which for a television receiver in the United States, can extend from 55 MHz of channel 2 of the lower VHF band to 847 MHz of
15 channel 69 of the UHF band, a frequency range of more than 17:1. This requires that the local oscillators for conventional all band TV tuners cover a wide frequency range of from approximately 90 MHz up to almost 1 GHz.

It is desirable that a local oscillator not be required to
20 tune over more than a range of 2:1, with an outside limit of about 3:1, due to problems of assuring that the oscillator will oscillate, reliability of frequency and signal amplitude of the generated oscillator signal over the wide spectrum, and tracking problems, since other circuits, e.g., tunable filters, must track as the local
25 oscillator frequency is changed. Further, varactor diodes, which typically are used to tune the local oscillator, have a limited range of adjustment and become non-linear in the low capacitance part of their adjustment range. For these reasons, in a television receiver, at a minimum, two local oscillators are often used with
30 each covering only part of the tunable spectrum, e.g., one for the VHF band and the other for the UHF band.

It is further desirable that a single oscillator be used in order to eliminate beat frequency problems between oscillators, which requires that oscillators not in use be turned off. Still
35 further, a reduced number of oscillators would result in reduced components, reduced printed circuit space, and reduced cost.

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**SUMMARY OF THE INVENTION**

A tuner includes a conversion (or heterodyning) stage, including a local oscillator and a mixer, for converting an RF signal
5 corresponding to a selected channel to a first IF signal. The local oscillator has only one tunable oscillating portion for generating a signal, and a controllable frequency converter, such as a controllable divider, for converting the frequency of the signals generated by said oscillating portion, so that the receiver is able to
10 tune through the UHF and VHF bands. The operation of the frequency converter is responsive to a digital channel selection controller, such as a microprocessor.

In one embodiment comprising a direct conversion tuner, the output signal of the local oscillator, when operated upon
15 by a phase shift network, can provide two local oscillator signals which are in quadrature phase. The quadrature signals are suitable for use in a direct conversion tuner which can tune the entire VHF and UHF bands.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows, in block diagram form, a prior art television tuner wherein a phase locked loop (PLL) is used to control a voltage controlled oscillator (VCO) serving as a first local oscillator (LO) in combination with a mixer for converting an RF
25 input signal to an IF signal.

Fig. 2 shows, in block diagram form, a VCO according to aspects of the present invention, including an oscillatory portion and a count down divider in a cascade arrangement.

Fig. 3 shows, in block diagram form according to
30 aspects of the present invention, an alternate embodiment of the local oscillator of Fig. 2, which is suitable for use in a direct conversion tuner.

Fig. 4 shows wave shapes found in the oscillator of Fig.
3.

35 Fig. 5 shows, in block diagram form according to aspects of the present invention, another alternate embodiment of



the oscillator of Fig. 2, which is suitable for use in a direct conversion tuner.

Fig. 6 shows, in block diagram form, a direct conversion tuner suitable for using the embodiments shown in Figs. 3 and 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A tuner 1 selects the RF signal corresponding to a selected channel from the plurality of RF signals provided by an RF source 3 and converts the selected RF signal to a corresponding IF signal in the conventional IF frequency range (e.g., in the United States between 41 and 46 MHz). RF source 3 may, for example, comprise a television broadcast receiving antenna, a cable distribution network, a video cassette recorder, a video disc player, or a home computer. The IF signal produced by tuner 1 is demodulated and separated into luminance, synchronization, chrominance and audio components by a video and audio signal processing unit 5. The various components are further processed by video and audio signal processing unit 5 to produce the video and audio responses corresponding to the selected channel.

The present tuner includes an RF input terminal 7 to which the RF source 3 is connected. The RF signals received at terminal 7 are filtered by an RF filter section 9 to select the RF signal corresponding to the selected channel and the resultant RF signal is coupled to a first mixer 11. A local oscillator (LO) signal having a nominal frequency corresponding to the selected channel is generated by an LO 13 and also coupled to first mixer 11. As shown in Fig. 1, LO 13 comprises a VHF local oscillator 13a and a VHF local oscillator 13b, with the appropriate oscillator being chosen by the bandswitching signal from channel selector 43, depending upon which channel is selected. Mixer 11 heterodynes the selected RF signal and the LO signal to produce an IF signal. Mixer 11 produces the sum and difference frequency products of the LO signal and the selected RF signal. The IF signal is coupled to an IF filter stage 15 which has a passband response selected to pass the difference frequency product of the LO signal and the

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selected RF signal. The frequencies of the LO signal determine the frequency range of the IF signal..

LO 13 is a voltage controlled oscillator and RF filter 9 are controlled in response to the magnitude of a tuning control voltage V_t . The magnitude of the tuning control voltage V_t is controlled in accordance with the selected channel by a tuner control section 25 including a phase locked loop (PLL). In the PLL, the frequency of the output signal of a crystal oscillator 27 is divided by a frequency divider (+R) 29 to produce a frequency reference signal. The PLL also includes a frequency divider (+K) 31 and a frequency divider (+N) 33 for dividing the frequency of the local oscillator signal to produce a frequency divided version of the LO signal. The frequency reference signal and the frequency divider local oscillator signal are compared by a phase comparator 35 to produce a pulse signal which represent the magnitude and sense of frequency deviation between them. The pulse error signal is filtered by an integrator 37, which serves as a low pass filter, to produce the tuning control voltage V_t for LO 13. The magnitude of the tuning control voltage is changed until the frequency of the frequency reference signal and the frequency divided LO signal are substantially equal.

Division factor R of divider 29 is selected to determine the frequency (f_{REF}) of the frequency reference signal. Division factor K of divider 31 is selected to reduce the frequency of the relatively high frequency LO signal before further processing and determines together with division factor R the division factor K. Division factor N of divider 33 is controlled by a control unit 39 to set the frequency of the first LO signal in accordance with the binary representation of the channel number of the desired channel stored in a register 41. The binary representation of the channel number is entered into channel number register 41 in response to a user's operation of a channel selector 43, which may, for example, comprise a calculator-like keyboard by which the user may enter in sequence the tens and units digits of the channel number of the desired channel.

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One aspect of the present invention, shown in Fig. 2, presents an embodiment of a local oscillator, e.g., local oscillator 13, which is able to tune over the wide frequency range of frequencies necessary for a television receiver, as discussed above 5 in the background section.

Tuning voltage V_t (see Fig. 1) is applied through an appropriate resistor 60 to varactor diode 62 for varying the capacitance of varactor diode 62 for tuning oscillating portion 64 of VCO 13, which in the exemplary embodiment, is an oscillator 10 which can be tuned from 0.5 to 1 GHz. The output signal 66 from oscillator 64 is coupled to a frequency divider control 68, which is a programmable binary counter which divides the oscillatory signal of oscillator 64 by a binary number in response to a divider control signal applied to terminal 70. The divider control signal at 15 terminal 70 can be provided by tuning control microprocessor 72 or it can be derived from channel selector 43 of Fig. 1 (not shown).

For a division number of 1, the output signal V_o is the same frequency as the frequency of oscillator 64, i.e., 500 to 1000 MHz tuned by V_t , and the frequency divider can be considered as 20 a divider bypass. For the oscillating frequency range of 500 MHz to 1000 MHz, as the division number of divider control 68 increases, the frequency of signal V_o decreases, as follows:

25	Division Number of divider 68	Frequency of V_o
	$N=2$	$F = 250 \text{ MHz to } 500 \text{ MHz}$
	4	125 MHz to 250 MHz
	8	62.5 MHz to 128 MHz
30	16	31.25 MHz to 62.5 MHz

The value of N is chosen for groups of channels and is changed when the channel chosen is in a different group. This table is an illustration as to the relationship of the frequency of 35 the oscillating portion 64 to the frequency of output signal V_o with a change of division number for divider 68. The frequency

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and range of oscillation of the oscillating portion 64 can be adjusted as required. Additionally, the frequencies chosen for V_o depend upon whether the sum or difference signals from the mixer are used as the IF signal.

5 In the alternative, oscillating portion 64 can oscillate at a much lower frequency, e.g., at a VHF frequency, and control 68 can be a frequency multiplier (not shown), e.g., a doubler or a tripler. In which case, V_o can achieve frequencies higher than the frequency signal generated by oscillatory portion 64.

10 Another embodiment is shown in Fig. 3. The embodiment of Fig. 3 has two additional divide by 2 circuits 74a, 74b and 90 degree phase shifted clocks 76 to obtain two output signals of quadrature phase V_{o1}, V_{o2} which are useful for direct conversion tuners discussed in connection with Fig. 6 below. The
15 wave forms of the embodiment of Fig. 3 are shown in Fig. 4 and show how the 90 degree phase shifted clocks 76 are obtained, using Q and not-Q clocks and dividing them both by two. The connection from the output of divider 74a synchronizes the two dividers 74a, 74b such that the clock of 74a always leads. This
20 embodiment shows an additional division by dividers 74a, 74b and thus, the voltage controlled oscillator 64 is tunable between the higher frequencies of 1 GHz to 2 GHz.

Another alternate embodiment with respect to Fig. 3, of a VCO 13 for a direct conversion tuner discussed in connection
25 with Fig. 6 below, is shown in Fig. 5 wherein the quadrature phase signals V_{o1}, V_{o2} for the UHF band is accomplished by two discrete LC phase shifter networks 76a, 76b for output frequencies at V_{o1}, V_{o2} above 500 MHz. For local oscillator frequencies below 500 MHz, the arrangement is switched so that
30 the quadrature phase signals V_{o1}, V_{o2} are produced by the divide by 2 divider as previously described with reference to Fig. 3. The output signals V_{o1}, V_{o2} are switched between the external components and the extra dividers 74a and 74b by switch 78.

Fig. 6 shows a direct conversion tuner according to PCT
35 patent application No. 94/00138. Basically, the direct conversion tuner contains two channels, each with two conversion stages.

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The received RF signal is coupled to each of two mixers M1A and M1B via a tuned RF amplifier which provides gain and some selectivity. Desirably, the gain of the RF amplifier is automatically controlled in response to an automatic gain control (AGC) signal (not shown). The first local oscillator signal generated by a first local oscillator LO1, such as shown in Figs. 3 and 5 discussed above, is tuned to the center frequency ω_0 of the frequency band of the desired channel between the lower side band (LSB) and the upper side band (USB). The first local oscillator signal is provided in quadrature components, V_{o1} , V_{o2} , that are used to drive mixers M1A and M1B. The respective IF output signals of mixers M1A and M1B are filtered by two low pass filters LPF A and LPF B. Low pass filters LPF A and LPF B provide the necessary selectivity to reject the responses from the adjacent channels and higher order products of mixers M1A and M1B.

Each of the output signals of mixers M1A and M1B includes both a lower side band portion and an upper side band portion corresponding to the LSB and USB portions of the received RF signal. The output signal of low pass filters LPF A and LPF B are coupled to respective ones of a second pair of mixers M2A and M2B. Mixers M2A and M2B are driven by respective ones of a second pair of quadrature local oscillator signals generated by a second local oscillator LO2, such as shown in Figs. 3 and 5. Each of the second local oscillator signals has a frequency ω_N located above the cutoff frequency of the low pass filters LPF A and LPF B filters to fulfill the Nyquist criteria. The output signals of mixers M2A and M2B are added in a summer unit SU to produce an output signal. This output signal is coupled to a demodulator (not shown) for demodulation, and the demodulated resultant is coupled to further signal processing sections.

WHAT IS CLAIMED IS:

1. A tuner for tuning RF signals corresponding to respective channels, each of said RF signals having at least one information bearing carrier, including a mixer and a local
5 oscillator means which cooperate for converting the RF signal corresponding to a selected channel to a first IF signal having an information bearing carrier corresponding to that of said selected channel, and control means for controlling said first local oscillator means, wherein:
 - 10 said local oscillator comprises an oscillating portion tunable in response to said control means and having an output signal tunable to frequencies over a predetermined range, and frequency converter means operating upon the tunable output signal and providing an oscillator output to said
15 mixer which is further tunable to frequencies outside of the predetermined range of the oscillating portion.
 2. The tuner of claim 1 wherein the frequency converter means is a programmable counter which is controllable by a digital controlling means.
 - 20 3. The tuner of claim 1 further comprising a phase shift means, for providing two local oscillator signals which are in quadrature phase, for the frequency conversion of signals in a direct conversion tuner.
 4. A television tuner for tuning channels with
25 respective RF signals with picture, color, and sound carriers, comprising:
 - local oscillator means for generating a local oscillator signal;
 - channel selector means for selecting one of said
30 channels;
 - local oscillator control means for controlling the frequency of said local oscillator signal in accordance with a channel selected by said channel selector means;
 - mixer means responsive to said RF signals and to said
35 first local oscillator signal for generating a IF signal having



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picture, color, and sound carriers corresponding to those of the RF signal of said selected channel;

said local oscillator means comprising an oscillating portion tunable in response to said control means and having an
5 output signal tunable to frequencies over a predetermined range, and

frequency converter means operating upon the tunable output signal and providing an oscillator output which is further tunable to frequencies outside of the predetermined range
10 of the oscillating portion.

5. The tuner of claim 4 wherein the frequency converter means is a programmable counter which is controlled by a microprocessor.

6. The tuner of claim 4 further comprising a phase
15 shift means for providing two local oscillator signals which are in quadrature phase for frequency conversion of signals in a direct conversion tuner.

7. The tuner of claim 4 wherein the frequency converter means is a frequency multiplier.

20 8. A television tuner for tuning channels of RF signals through the VHF and UHF bands, said tuner having a local oscillator and a mixer for converting said RF source signals to an intermediate frequency signal, said local oscillator having only one tunable oscillating portion and a frequency converter for
25 converting the frequency of the signals generated by said oscillating portion, the combination of the single tunable oscillating portion and the frequency converter being tunable for tuning the television tuner through the UHF, and the upper and lower VHF bands.

30 9. The television tuner of claim 8 wherein the frequency converter is a frequency divider.

10. The television tuner of claim 9 wherein the frequency divider is a programmable counter.



11. A television tuner for tuning channels of RF signals through the VHF and UHF bands, said tuner having a conversion means for converting the frequency of received RF signals to an intermediate frequency, said conversion means comprising:

means for receiving the RF signals,
means for generating a local oscillator signal, and
means for mixing the local oscillator signal with the RF signals for producing an IF signal,

said means for generating a local oscillator signal comprising an oscillating portion which is tunable, and a frequency converter in cascade with the oscillating portion for operating upon the signal generated by the oscillating portion.

12. The television tuner of claim 11 wherein the frequency converter is a frequency divider.

13. The television tuner of claim 12 wherein the frequency divider is a programmable counter.

14. The television tuner of claim 11 wherein the frequency converter is a frequency multiplier.

15. A television tuner for tuning the television spectrum through the VHF and UHF bands, said tuner having a mixer for mixing the received RF signals with a local oscillator signal for producing an IF signal, said tuner having only a single local oscillator.



.1 This Sheet Has Been Replaced

