

TUNER FOR DIGITAL SATELLITE RECEIVER

The invention concerns a tuner for a satellite receiver, especially one capable of receiving and processing television signals transmitted in digital form.

A satellite television receiving system includes an "outdoor unit", including a dish-like receiving antenna and a "block" converter, and an "indoor unit" including a tuner and a signal processing section. The block converter converts the entire range of relatively high frequency RF signals transmitted by the satellite to a more manageable, lower range of frequencies.

In a conventional satellite television receiving system for receiving and processing television information transmitted in analog form, the RF signals transmitted by the satellite are in the C (3.7 to 4.2 GigaHertz) and Ku (11.7 to 14.2.2 GigaHertz) bands, and are converted by the block converter to the L band (900 to 2000 MegaHertz) as a "block". An RF filter section of the tuner of the indoor unit selects the one of the RF signals provided by the block converter corresponding to the selected channel and the selected RF signal is again converted by a mixer/local oscillator section of the tuner to a lower, intermediate frequency (IF) range for filtering and demodulation. Typically, the IF frequency range has a center frequency of 479 MegaHertz. Analog satellite television systems typically employ FM modulation, and a baseband video signal is readily obtained from the 479 IF signal by an FM demodulator after filtering by an IF filter. A relatively simple surface acoustic wave (SAW) device can provide adequate filtering.

In newer satellite television systems, such as the DSS™ (Direct Satellite System) available from Thomson Consumer Electronics of Indianapolis, Indiana, television information is transmitted in digital form. RF signals are transmitted by the satellite in the Ku band, and are converted by the block converter to the L band. The frequency range of the RF signals transmitted by the satellite is somewhat smaller, e.g., between 12.2 and 12.7 GigaHertz, than that for the analog satellite television system, and

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the frequency range of RF signals produced by the block converter is accordingly somewhat smaller, e.g., between 950 and 1450 MegaHertz. As in the analog satellite television receiving systems, the RF signal corresponding to the selected channel has to be
5 reduced in frequency to an IF frequency range for filtering and demodulation. However, the type of filtering ("symbol shaping") required in digital satellite television receiver, cannot readily be performed at the relatively high IF frequency (e.g., 479 MegaHertz) employed in an analog satellite television receiver,
10 especially using a SAW device. As a result, a relatively expensive digital filter will be required for filtering the demodulated digital signals. Alternatively, the tuner can employ a second conversion stage to convert the relatively high frequency (e.g., 479 MegaHertz) first IF signal to a second, lower frequency (e.g., less
15 than 100 MegaHertz) signal for filtering. However, the second conversion stage adds undesirable cost to the receiver.

It is also desirable that the tuner of the digital satellite television receiver be capable of being constructed utilizing components which are already commercially available and
20 therefore relatively inexpensive. Specifically, in this regard it is desirable that the tuner be capable of being constructed utilizing a commercially available integrated circuit (IC) which incorporates a phase locked loop (PLL) for controlling the frequency of the local oscillator. Since a large number of tuner PLL ICs for conventional
25 television receivers which receive and process conventional broadcast and cable television signals are widely available, it is particularly desirable that the tuner of the digital satellite television receiver be capable of being constructed utilizing such a conventional tuner PLL IC.

30 In accordance with an aspect of the invention, the tuner of a digital satellite television receiver comprises a single conversion stage for converting the selected RF signal received from the block converter of the outdoor unit to an IF signal within a frequency range which permits the use of a SAW device for
35 "symbol shaping" the IF signal as is required for the transmission of information in digital form. For the reasons to be described

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below in detail with reference to the exemplary embodiment of the invention, providing for an IF signal having a center frequency in the order of 140 MegaHertz (MHz) satisfies these requirements. However, different IF frequencies are possible, and, according to another aspect of the invention, in general terms, the IF frequency may be selected to be in the order of the difference between the highest frequency of the RF signal received from the block converter (e.g., 1450 MHz) and highest local oscillator frequency (1300 MHz) available by utilizing a conventional tuner PLL IC normally utilized in conventional broadcast and cable television receivers.

Various aspects of the invention will be described in detail with reference to the accompanying Drawing in which:

Figure 1 is a block diagram of a digital satellite television receiving system including a tuner constructed in accordance with an aspect of the invention;

Figure 2 is a block diagram of a phase locked loop tuning control integrated circuit used in the tuner shown in Figure 1;

Figure 3 is an idealized amplitude versus frequency response of a SAW device employed in the tuner shown in Figure 1; and

Figure 4 is graphical representation of certain characteristics of a SAW device as a function of temperature and frequency which are useful in understanding the selection of the particular type of SAW device which is desirably utilized in the tuner shown in Figure 1.

The invention will be described with reference to a digital satellite television system in which television information is transmitted in encoded and compressed form in accordance with a predetermined digital compression standard, such as MPEG. MPEG is an international standard for the coded representation of moving picture and associated audio information developed by the Motion Pictures Expert Group. The television information is represented by a series or stream of digital signals organized into packets corresponding to respective video and audio portions of

the television information. The digital signals are modulated on a RF carrier signal in what is known as QPSK (Quaternary Phase Shift Keying) modulation and the RF signal is transmitted to a satellite in earth orbit, from which it is retransmitted back to the earth. A satellite typically includes a number of transponders for receiving and retransmitting respective modulated RF carriers. The DirecTv™ satellite television transmission system operated by the Hughes Corporation of California is such a digital satellite television transmission system.

10 In the digital satellite television receiving system shown in Figure 1, RF signals modulated with digital signals representing video and audio information are transmitted by a satellite (not shown) and received by a dish-like antenna 1. The relatively high frequency received RF signals (e.g., in the Ku
15 frequency range between 12.2 and 12.7 GigaHertz) are converted by a block converter 3 to relatively a lower frequency RF signals (e.g., in the L band between 950 and 1450 MHz). Block converter 3 includes a low noise amplifier and is therefore often referred to by the initials "LNB". Antenna 1 and LNB 3 are included in a so
20 called "outdoor unit" 5 of the receiving system. The remaining portion of the receiving system is included in a so called "indoor unit" 7.

Indoor unit 7 includes a tuner 9 for selecting the particular RF signal corresponding to the desired channel from the
25 plurality of RF signals received from outdoor unit 5 and for converting the selected RF signal to a lower, intermediate frequency (IF) signal. Tuner 9 is constructed in accordance with the present invention and will be described in detail below.

A QPSK demodulator 11 demodulates the output signal
30 of tuner 9 to produce two analog, quadrature phase digital signals (I and Q). A decoder 13 produces a stream of video and audio packets from the I and Q signals. Decoder 13 includes analog to digital converters for converting the analog I and Q signals to respective series of digital samples and an error corrector which
35 corrects transmission errors based on error codes embed in the transmitted digital signals. The video and audio packets of the

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digital stream produced by decoder 13 are routed by a transport unit 15 to respective sections of a digital signal processing (DSP) unit 17.

The digital satellite television receiver described so far is similar to the DSS™ satellite television receiver commercially available from Thomson Consumer Electronics, Inc. of Indianapolis, Indiana. The present invention is concerned with details of the implementation of tuner 9.

Tuner 9 receives the RF signal provided by LNB 3 at an input 901. The RF input signals are filtered by a wideband filter 203, amplified by an RF amplifier 905, and filtered by a tunable bandpass filter 907. The resultant RF signal is coupled to a first input of a mixer 909. A local oscillator signal produced by a local oscillator (LO) 911 is coupled to a second input of mixer 909. The output of mixer 909 is amplified by an amplifier 912 and coupled to the input of an IF filter 913 comprising a SAW device. The output of IF filter 913 is coupled to output 915 of tuner 9.

The frequency of local oscillator 911 is controlled by a phase locked loop (PLL) 917 comprising an integrated circuit (IC). The frequency of the LO signal is controlled by the PLL IC in accordance with data generated by a microprocessor 919.

As shown in Figure 2, the PLL IC includes a "prescaler" frequency divider 917-1 for dividing the frequency of the LO signal followed by a programmable frequency divider (+N) 917-3. The PLL IC also includes an amplifier 917-5, which in combination with an external crystal network 917-7, comprises a reference frequency oscillator. The output of the reference frequency oscillator is coupled to the input of a reference frequency divider (+R) 917-9. The output signals of programmable divider (+N) 917-3 and reference divider (+R) 917-9 are coupled to respective inputs of a phase detector 917-11. The output signal of phase detector 917-11 is coupled to an amplifier 917-13, which together with an external filter network 917-15, comprises an integrator for producing a control voltage for LO 911. When the phase locked loop is locked, the frequency of the LO signal is

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proportionally related to the frequency of the reference frequency signal produced by reference frequency divider (+R) 917-9 by the programmable division factor (N) of programmable divider (+N) 917-3. Programmable division factor N is controlled by data
5 generated by microprocessor 919.

As earlier noted, it is desirable that the tuner have the following three characteristics: (1) include only a single conversion stage; (2) provide an IF signal with a low enough frequency to allow a SAW device to be used for digital symbol shaping, as well
10 as normal IF filtering; and (3) be capable of being constructed utilizing a PLL tuning control IC conventionally used for broadcast and cable receivers. This is accomplished in the present tuner by selecting the center frequency of the IF signal to be 140 MHz and controlling the frequency of the LO signal to be 140 MHz below
15 the frequency RF signal for the respective channel (transponder). As a result, with a frequency range for RF input signal between 950 and 1450 MHz, the frequency range of the LO signal is between 810 and 1310 MHz. The 140 MHz IF frequency allows a SAW device with the required characteristics, as will be described
20 below, to be used. The 810-1310 MHz frequency range of the LO signal permits a PLL tuning control IC conventionally used for broadcast and cable receivers to be used. Such an IC is the TSA5515T commercially available from Philips Semiconductors and others. It is noted in this regard that the maximum LO
25 frequency available using the TSA5515T and similar ICs is in the order of 1300 MHz, which is adequate.

It will be noted that different IF frequencies are possible, and, in general terms, the IF frequency may be selected to be in the order of the difference between the highest frequency
30 of the RF signal received from the LNB and highest local oscillator frequency available by utilizing a conventional tuner PLL IC normally utilized in conventional broadcast and cable television receivers.

Desirably, tunable bandpass filter 907 should remove
35 the image of the desired RF signal which is at a frequency 280 MHz below the frequency of the desired RF signal.

In a digital transmission system, it is desirable to perform what is known as "symbol shaping" to provide a signal relatively free of intersymbol interference. Such interference may be produced due to improper filtering of high frequency energy of the pulse components of digital signals in the transmitter due to bandwidth limitations. The desired symbol shaping function may be shared between the transmitter and the receiver. In the receiver, it is desirable that the IF filter provide for symbol shaping, as well as the normal IF filtering function, so that a separate digital filter not be required. By way of example, the IF filter may provide what is known in the digital filter arts as a "root raised cosine" response. Such a response is shown in Figure 3. A SAW device may be used to provide symbol shaping provided that its characteristics are carefully selected.

Two properties of a SAW filter are considered important for application in a tuner of a digital satellite television receiver. These are: (1) the overall shift or offset of the filter characteristic (i.e., the shift of the center frequency) with temperature; and (2) the change of the relative bandwidth (i.e., the passband width divided by the center frequency).

The most common type of SAW device utilizes lithium niobate (LiNbO_3) as a substrate. A lithium niobate SAW has a typical temperature coefficient of -90 ppm/degree C. The present tuner employs another type of SAW which utilizes lithium tantalate (LiTaO_3) as a substrate. A lithium tantalate SAW has a typical temperature coefficient of -23 ppm/degree C. Assuming a temperature range of -20 to $+70$ degree C, and a center frequency of 140 MHz, the following evaluation can be made with regard to frequency shift with temperature:

lithium niobate produces a temperature drift of
 $140\text{E}6 \times -90\text{E}-6 \times \pm 45 = \pm 567.0$ Hz; and
lithium tantalate produces a temperature drift of
 $140\text{E}6 \times -23\text{E}-6 \times \pm 45 = \pm 144.9$ Hz.

Assuming that a shift of 500 kHz, which may produce a noise margin degradation of slightly less than 0.1 dB, is undesirable, a lithium niobate SAW exceeds the 500 kHz goal over the range of

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temperature variation. To use a lithium niobate SAW, the center frequency would have to be reduced to 123 MHz or lower to maintain the 500kHz goal. With a lithium tantalate SAW, the center frequency only has to be 483 MHz or lower.

5 As to relative bandwidth, the following is noted.

Generally, wider relative bandwidth filters are more difficult to make, and filters with relative bandwidth in excess of 15 to 18% require the use of a lithium niobate SAW. Lesser relative bandwidth requirements allow the use of either type of SAW. A
10 20 MHz wide filter with a center frequency at 140 MHz has only a relative bandwidth of 14%. If a 18% relative bandwidth were required, an IF center frequency of 110 MHz would be required.

Figure 4 graphically summarizes the characteristics discussed above. Figure 4 shows the frequency regions where a
15 lithium niobate SAW or a lithium tantalate SAW or both may satisfy the temperature drift and relative bandwidth requirements, and the result when both requirements are considered. As can be seen: an IF frequency below 110 MHz requires a lithium niobate SAW filter; an IF between 110 MHz and
20 123 MHz may utilize either a lithium niobate SAW or a lithium tantalate SAW; an IF between 123 MHz and 483 MHz requires a lithium tantalate SAW, and a SAW for an IF beyond 483 MHz cannot satisfy the requirements due to excessive temperature drift. For a 140 MHz center frequency, a lithium tantalate SAW
25 should be used.



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CLAIMS

1. In a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit (5) including a satellite receiving antenna (1) and a block converter (3), a tuner (9) comprising:

an RF input for receiving a plurality RF signals provided by said block converter (3);

a local oscillator (911) for generating a local oscillator signal;

a mixer (909) having a first input coupled to said RF input, a second input coupled to said local oscillator (911) and an output at which an IF signal is produced;

a surface acoustic wave filter (913) coupled to said output of said mixer (909) for filtering said IF signal including intersymbol shaping; and

a phase locked loop tuning control integrated circuit for controlling the frequency of said local oscillator (911); said phase locked loop tuning control integrated circuit being of the type which is normally utilized in conventional terrestrial broadcast and cable television receivers.

2. The apparatus recited in claim 1, wherein:

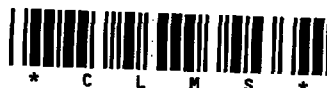
the frequency of the IF signal is selected to be in the order of the difference between the highest frequency of said RF signals received from said block converter (3) and the highest local oscillator frequency available by utilizing said phase locked loop tuning control integrated circuit.

3. The apparatus recited in claim 2, wherein:

said block converter (3) provides RF signals in a frequency range in the order of 950 to 1450 MHz and said local oscillator (911) has a frequency range in the order of 810 to 1310 MHz.

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4. The apparatus recited in claim 3, wherein:
said IF signal has a nominal frequency of 140 MHz.

5 5. In a digital satellite television receiver for receiving
and processing digital signals modulated on respective ones of a
plurality of RF signals received from an outdoor unit including a
microwave satellite receiving antenna (1) and a block converter
(3), apparatus comprising:
10 an RF input for receiving said plurality of RF signals
provided by said block converter (3);
 a local oscillator (911) for generating a local oscillator
signal;
 a mixer (909) having first input coupled to said RF
15 input, a second input coupled to said local oscillator (911), and an
output at which an IF signal is produced; and
 a surface acoustic wave filter (913) coupled to said
output of said mixer (909) for filtering said IF signal; said surface
acoustic wave filter (913) being capable of symbol shaping for
20 reducing intersymbol interference; said surface acoustic wave
filter (913) having a nominal center frequency greater than 110
MHz and significantly less than 479 MHz.

 6. The apparatus recited in claim 5, wherein:
25 said block converter (3) provides RF signals in a
frequency range in the order of 950 to 1450 MHz and said local
oscillator (911) has a frequency range in the order of 810 to 1310
MHz.

30 7. The apparatus recited in claim 6, wherein:
said nominal frequency of said IF signal is 140 MHz.

 8. The apparatus recited in claim 5, wherein:
said local oscillator (911) is included in a phase locked
35 loop (911, 917) for controlling the frequency of said local
oscillator (911).

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9. The apparatus recited in claim 8, wherein:
said phase locked loop includes a phase locked loop
tuning control integrated circuit of the type which is normally
5 utilized in conventional terrestrial broadcast and cable television
receivers.

10. The apparatus recited in claim 9, wherein:
the frequency of the IF signal is selected to be in the
order of the difference between the highest frequency of said RF
10 signals received from said block converter (3) and the highest
local oscillator frequency available by utilizing said phase locked
loop tuning control integrated circuit.

11. The apparatus recited in claim 10, wherein:
15 said block converter (3) provides RF signals in a
frequency range in the order of 950 to 1450 MHz and said local
oscillator (911) has a frequency range in the order of 810 to 1310
MHz.

12. The apparatus recited in claim 11, wherein:
20 said nominal frequency of said signal is 140 MHz.

13. In a digital satellite television receiver for
receiving and processing digital signals modulated on respective
25 ones of a plurality of RF signals received from an outdoor unit (5)
including a satellite receiving antenna (1) and a block converter
(3), a tuner comprising:

an RF input for receiving a plurality RF signals
provided by said block converter (3);
30 a local oscillator (911) for generating a local oscillator
signal;

a mixer (909) having a first input coupled to said RF
input, a second input coupled to said local oscillator (911) and an
output at which an IF signal is produced;

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a surface acoustic wave filter (913) coupled to said output of said mixer (909) for filtering said IF signal including intersymbol shaping; and

a phase locked loop tuning control integrated circuit 5 for controlling the frequency of said local oscillator (911); said phase locked loop tuning control integrated circuit being of the type which is normally utilized in conventional terrestrial broadcast and cable television receivers;

the frequency of the IF signal being selected to be in 10 the order of the difference between the highest frequency of the RF signal received from the block converter (3) and highest local oscillator frequency available by utilizing said phase locked loop tuning control IC.

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14. The apparatus recited in claim 13, wherein:

said block converter (3) provides RF signals in a frequency range in the order of 950 to 1450 MHz and said local oscillator (911) has a frequency range in the order of 810 to 1310 MHz.

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15. The apparatus recited in claim 14, wherein:
said nominal frequency of said signal is 140 MHz.

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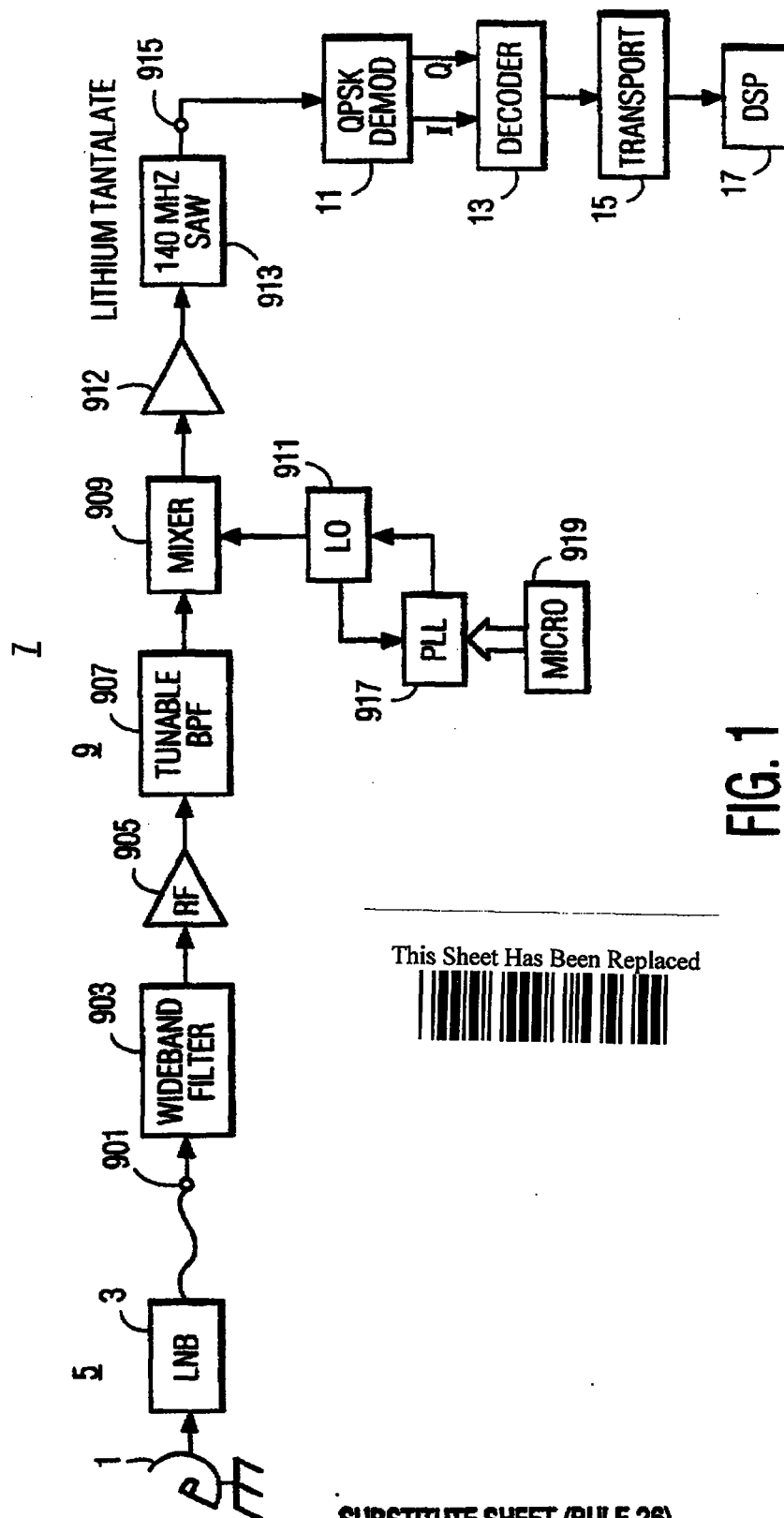


FIG. 1

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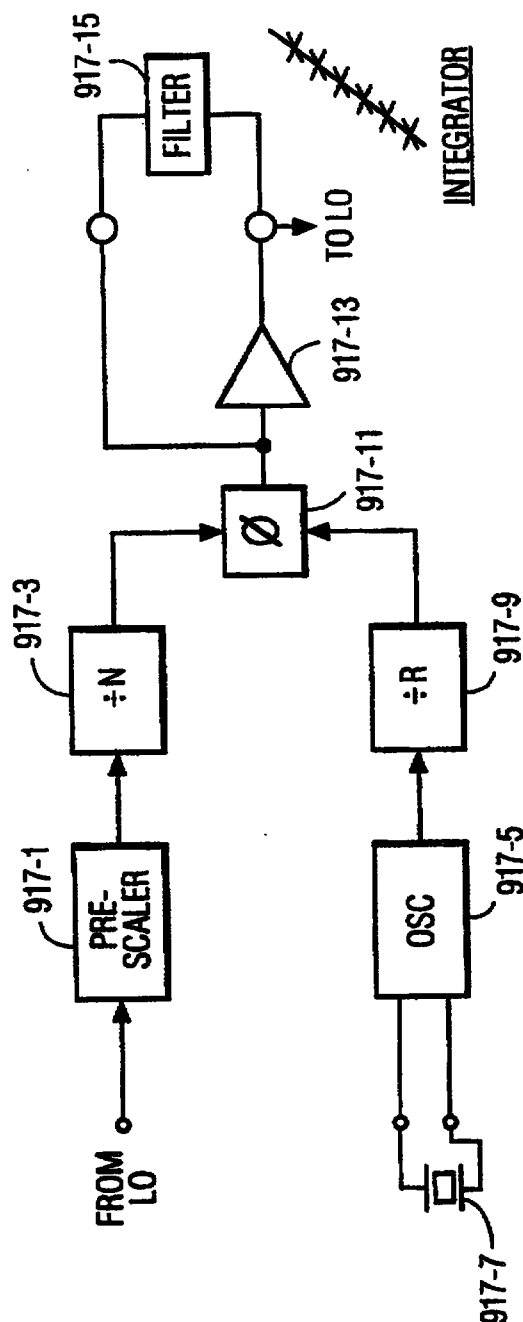


FIG. 2

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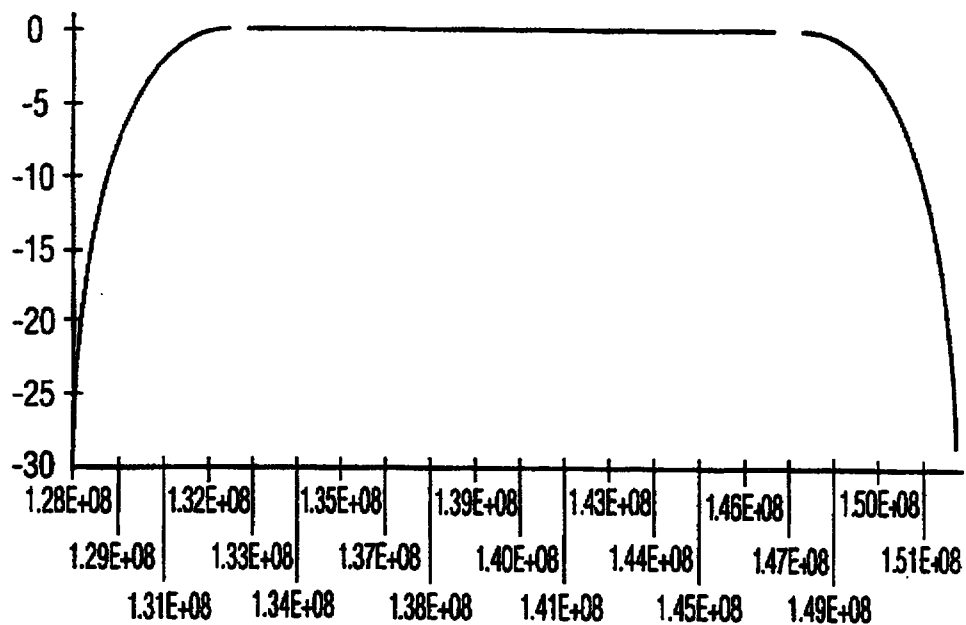


FIG. 3

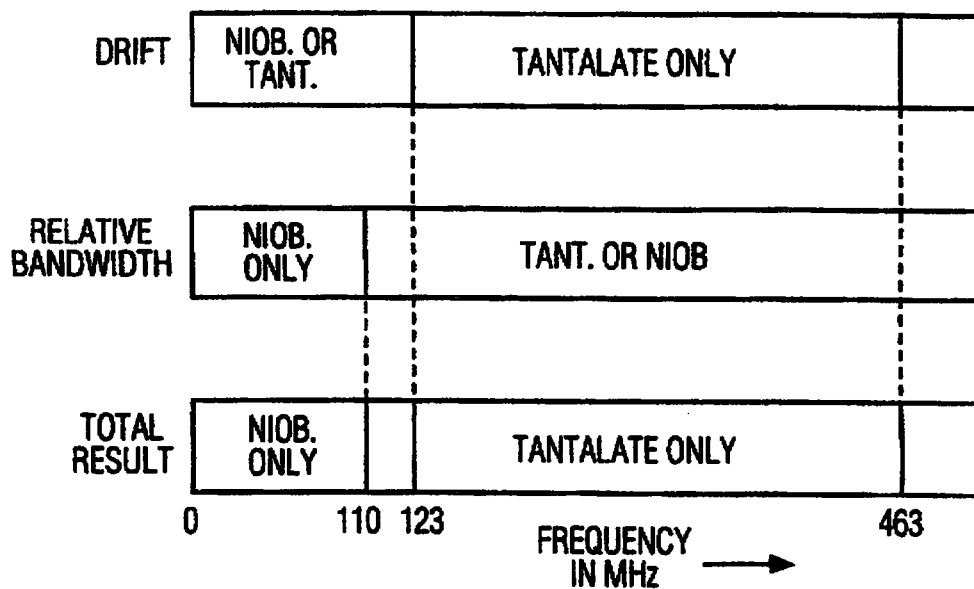


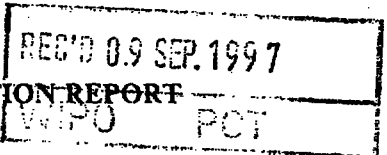
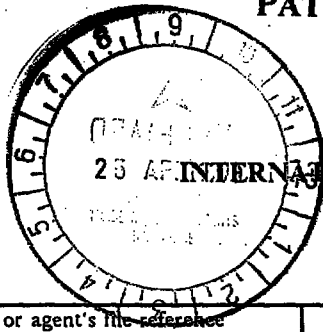
FIG. 4

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(PCT Article 36 and Rule 70)

Applicant's or agent's file reference RCA 87543	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US 96/ 07673 ✓	International filing date (day/month/year) 28/05/1996 ✓	Priority date (day/month/year) 06/06/1995 ✓
International Patent Classification (IPC) or national classification and IPC H03J1/00		
Applicant THOMSON CONSUMER ELECTRONICS, INC. ✓		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

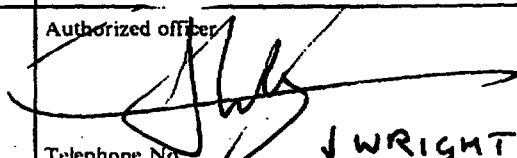
2. This REPORT consists of a total of 8 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consists of a total of 3 sheets.

3. This report contains indications and corresponding pages relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 06/12/1996	Date of completion of this report - 5. 09. 97
Name and mailing address of the IPEA;  European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	Authorized officer  J. WRIGHT Telephone No.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

Intern. application No.

PCT/US96/07673

I. Basis of the report

1. This report has been drawn up on the basis of (Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.):

☐ the international application as originally filed.

☒ the description, pages 2-8 _____, as originally filed,
pages _____, filed with the demand,
pages 1, 1a _____, filed with the letter of 22.08.97,
pages _____, filed with the letter of _____.

☒ the claims, Nos. _____, as originally filed,
Nos. _____, as amended under Article 19,
Nos. _____, filed with the demand,
Nos. 1-4 _____, filed with the letter of 22.08.97,
Nos. _____, filed with the letter of _____.

☒ the drawings, sheets/fig _____, as originally filed,
sheets/fig _____, filed with the demand,
sheets/fig 1/3-3/3 _____, filed with the letter of 11.07.96,
sheets/fig _____, filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

☐ the description, pages _____.

☐ the claims, Nos. _____.

☐ the drawings, sheets/fig _____.

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

It is noted that the term "as originally filed" is taken to include those sheets which were deemed not to have been filed at the time of the original search, but which

were later accepted by the USPTO on production of evidence by the applicant to have been legitimately filed with the other documents on 28.05.96.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

Intern. application No.

PCT/US96/07673

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims 1-4	YES
	Claims	NO
Inventive Step (IS)	Claims 2-4	YES
	Claims 1	NO
Industrial Applicability (IA)	Claims 1-4	YES
	Claims	NO

2. CITATIONS AND EXPLANATIONS

5 In the following section the patentability of the claims will be discussed in relation to the prior art available to the examiner.

The following documents are mentioned in this preliminary report; the numbering will be adhered to in the rest of the procedure:

D1 US-A-5,325,401 [HALIK et al]

D2 GB-A-2,228,383 [KABUSHIKI KAISHA TOSHIBA]

5.1 Claim 1

Claim 1 is not allowable because it lacks an inventive step, Art. 33 PCT. Using as far as possible the wording of claim 1 but referring to D1, D1 discloses the following:

A digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a satellite receiving antenna (1) and a block converter (18) , a tuner (170,25) comprising:

an RF input for receiving a plurality of RF signals provided by said block converter;

a local oscillator (170) for generating a local oscillator signal (119);

a mixer (25) having a first input coupled to said RF input, a second input coupled to said local oscillator (170) and an output at which an IF signal is produced;

Whereby the receiver also includes

a phase locked loop tuning control integrated circuit (170).

The feature that the phase locked tuning control is "suitable for use in conventional terrestrial broadcast and cable television receivers" does not itself represent an inventive step. The person skilled in the art would always wish to use devices which were common in the art, thereby saving costs by using none specialist devices.

In application as a whole it is not claimed what particular features contribute to the selection of such a device being possible.

It is furthermore noted that "intersymbol shaping" which, from the application as a whole is taken to mean the filtering of a signal such that influences from ad-

jacent elements of data do not effect the present data is a feature of any digital signal system.

The remaining features of the claim include the use of a SAW device as a filter and intersymbol shaper.

It is always the desire of the person skilled in the art to simplify design of a particular circuit or device. The person skilled in the art would be aware of an analogous device in the analogue domain which provided a IF signal using only a single intermediate frequency stage and arriving at a centre frequency which was suitable for digital satellite television receiver. Such a device is disclosed in D2.

Using as far as possible the wording of claim 1 but referring to D2, D2 discloses the following:

A satellite television receiver for receiving and processing signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a satellite receiving antenna and a block converter (1), a tuner (2) comprising:

an RF input (8) for receiving a plurality of RF signals provided by said block converter;

a local oscillator (11) for generating a local oscillator signal;

a mixer (10) having a first input coupled to said RF input, a second input coupled to said local oscillator (11) and an output at which an IF signal is produced;

a surface acoustic wave filter (D2 page 6, line 25-page 7 line 1) coupled to said output of said mixer for filtering said IF signal.

The person skilled in the art, wishing to simplify the design of the circuit known from D1 would introduce the advantageous features of D2 without making an inventive step. In so doing the person skilled in the art would therefore arrive at the features of the current claim 1 of the application without having made an inventive step. Claim 1 does not therefore fulfil the conditions laid down in Art. 33(3) PCT, since the claim lacks an inventive step.

5.2 Claim 2

The examiner considers that taking into account the argumentation laid down in the application, page 6, lines 12-15, it would seem that the features of claim 2 of the application enable the circuit claimed in claim 1 to function. As such it would appear that the subject matter of claim 2 contains the essential inventive concept enabling the circuit to work and appears as such to contain subject matter which could have lead to an allowable independent claim.

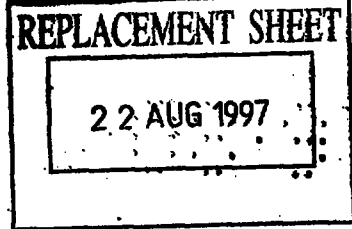
5.3 Claims 3 and 4

Claims 3 and 4 would have been allowable since claim 2 from which they take dependency is considered to be new and to involve an inventive step.

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

The description should be modified in accordance with the newly filed claims, such that it discloses the invention as claimed in accordance with Rule 5.1(iii). This may be achieved with a simple statement to the effect that the invention is defined by the appended claims.



TUNER FOR DIGITAL SATELLITE RECEIVER

The invention concerns a tuner for a satellite receiver, especially one capable of receiving and processing television signals transmitted in digital form.

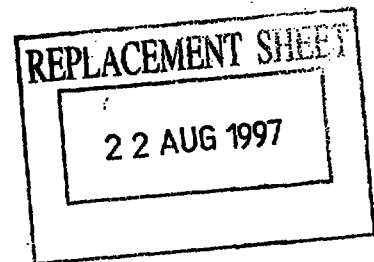
A satellite television receiving system includes an "outdoor unit" including a dish-like receiving antenna and a "block" converter and an "indoor unit" including a tuner and a signal processing section. The block converter converts the entire range of relatively high frequency RF signals transmitted by the satellite to a more manageable, lower range of frequencies.

In a conventional satellite television receiving system for receiving and processing television information transmitted in analog form, the RF signals transmitted by the satellite are in the C (3.7 to 4.2 GigaHertz) and Ku (11.7 to 14.2 GigaHertz) bands, and are converted by the block converter to the L band (900 to 2000 MegaHertz) as a "block". An RF filter section of the tuner of the indoor unit selects the one of the RF signals provided by the block converter corresponding to the selected channel and the selected RF signal is again converted by a mixer/local oscillator section of the tuner converted to a lower, intermediate frequency (IF) range for filtering and demodulation. Typically, the IF frequency range has a center frequency of 479 MegaHertz. Analog satellite television systems typically employ FM modulation, and a baseband video signal is readily obtained from the 479 IF signal by an FM demodulator after filtering by an IF filter. A relatively simple surface acoustic wave (SAW) device can provide adequate filtering. Examples of conventional satellite television receiving systems may be found in US 5,325,401 by Halik et al. entitled L-BAND TUNER WITH QUADRATURE DOWNCONVERTER FOR PSK DATA APPLICATIONS, and in GB 2 228 383 by O. Hideki entitled SERIES CONNECTED BAND SWITCHING FILTERS AND SATELLITE BROADCAST RECEIVING SYSTEM USING THE SAME.

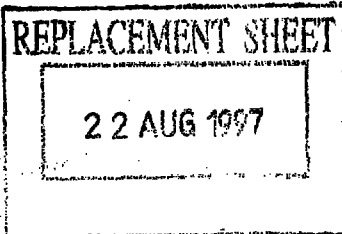
In newer satellite television systems, such as the DSS™ (Direct Satellite System) available from Thomson Consumer Electronics of Indianapolis, Indiana, television information is transmitted in digital form. RF signals are transmitted by the satellite in the Ku band, and are converted by the block converter to the L band. The frequency range of the RF signals transmitted by the satellite is somewhat smaller, e.g.,

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between 12.2 and 12.7 GigaHertz, than that for the analog satellite television system, and



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CLAIMS

1. In a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit (5) including a satellite receiving antenna (1) and a block converter (3), a tuner (9) comprising:

an RF input for receiving a plurality of RF signals provided by said block converter (3);

a local oscillator (911) for generating a local oscillator signal;

a mixer (909) having a first input coupled to said RF input, a second input coupled to said local oscillator (911) and an output at which an IF signal is produced;

a surface acoustic wave filter (913) coupled to said output of said mixer (909) for providing filtering of said IF signal including symbol shaping for reducing intersymbol interference; and

a phase locked loop tuning control integrated circuit for controlling the frequency of said local oscillator (911); said phase locked loop tuning control integrated circuit being suitable for use in conventional terrestrial broadcast and cable television receivers.

2. The apparatus recited in claim 1, wherein:

the frequency of the IF signal is selected to be in the order of the difference between the highest frequency of said RF signals received from said block converter (3) and the highest local oscillator frequency available by utilizing said phase locked loop tuning control integrated circuit.

3. The apparatus recited in claim 2, wherein:

said block converter (3) provides RF signals in a frequency range in the order of 950 to 1450 MHz and said local oscillator (911) has a frequency range in the order of 810 to 1310 MHz.

4. The apparatus recited in claim 3, wherein said IF signal has a nominal frequency of 140 MHz.

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APPENDIX B

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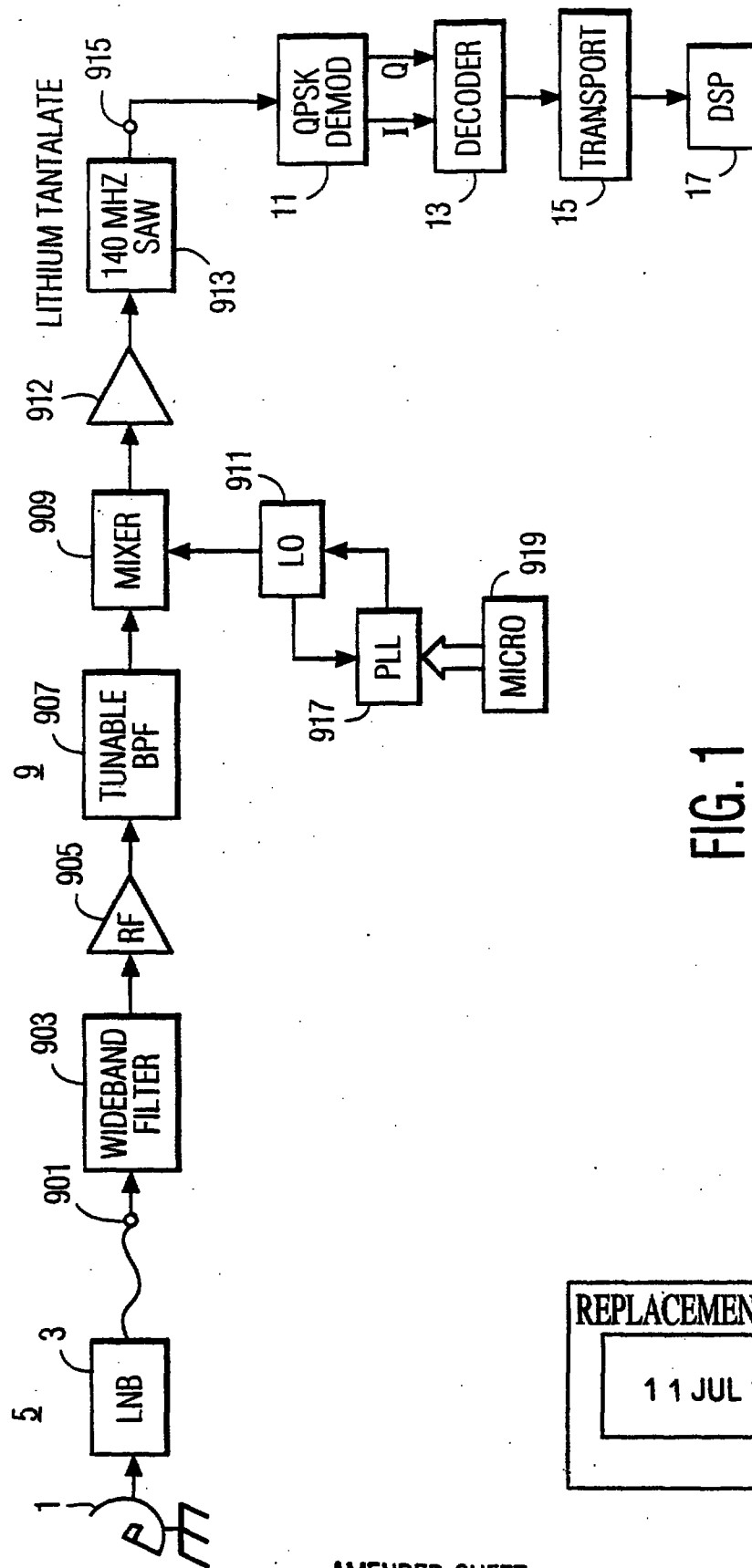


FIG. 1

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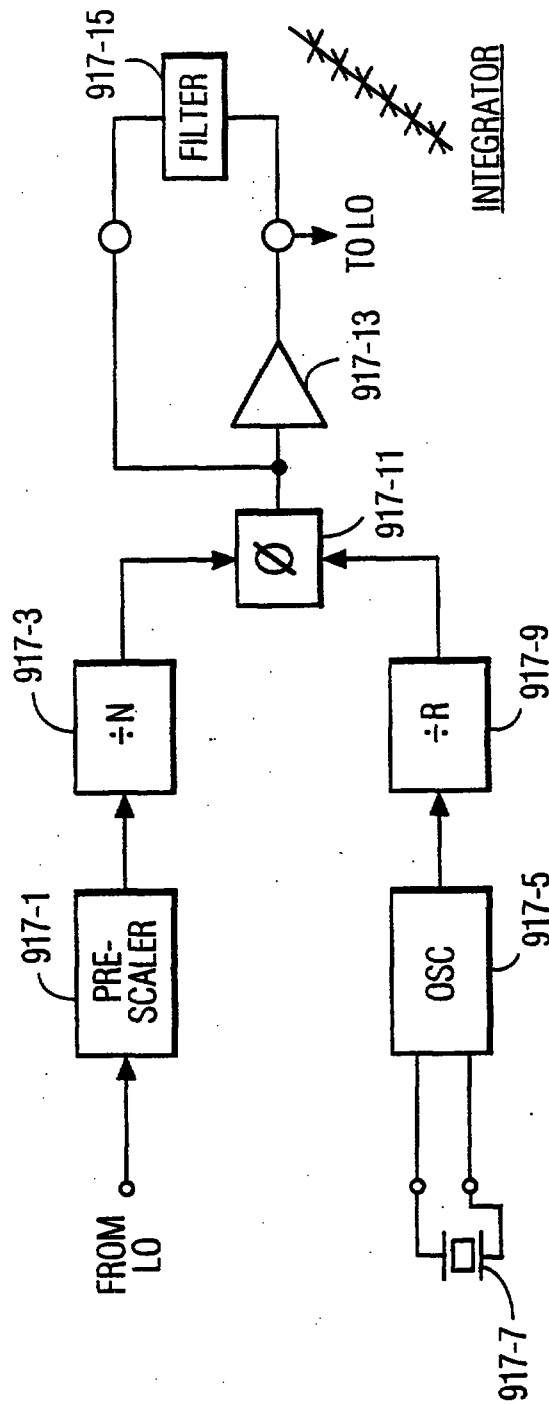


FIG. 2

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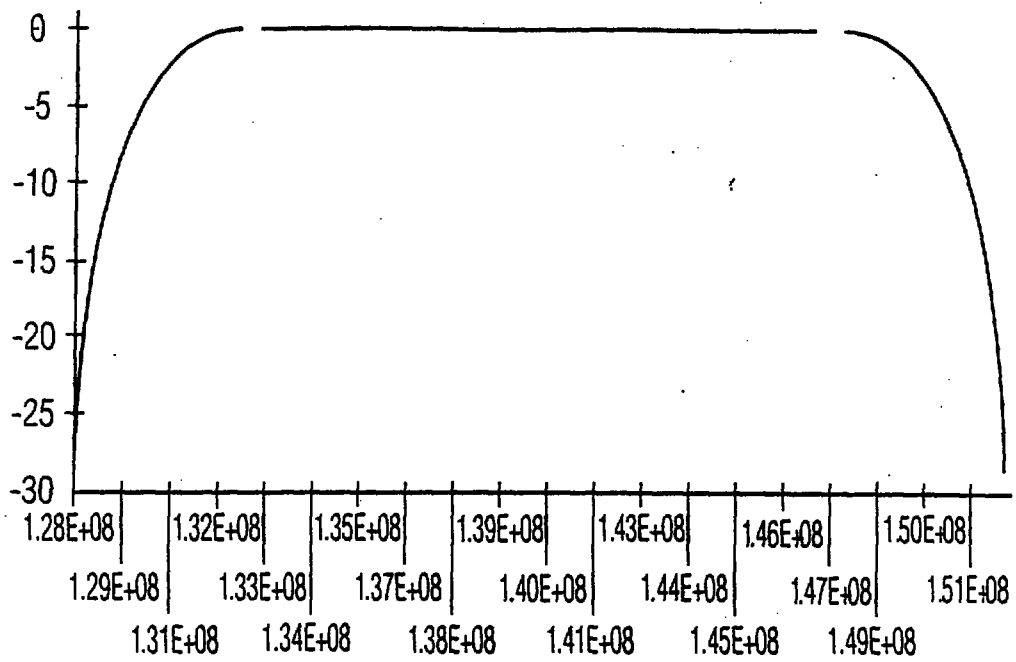


FIG. 3

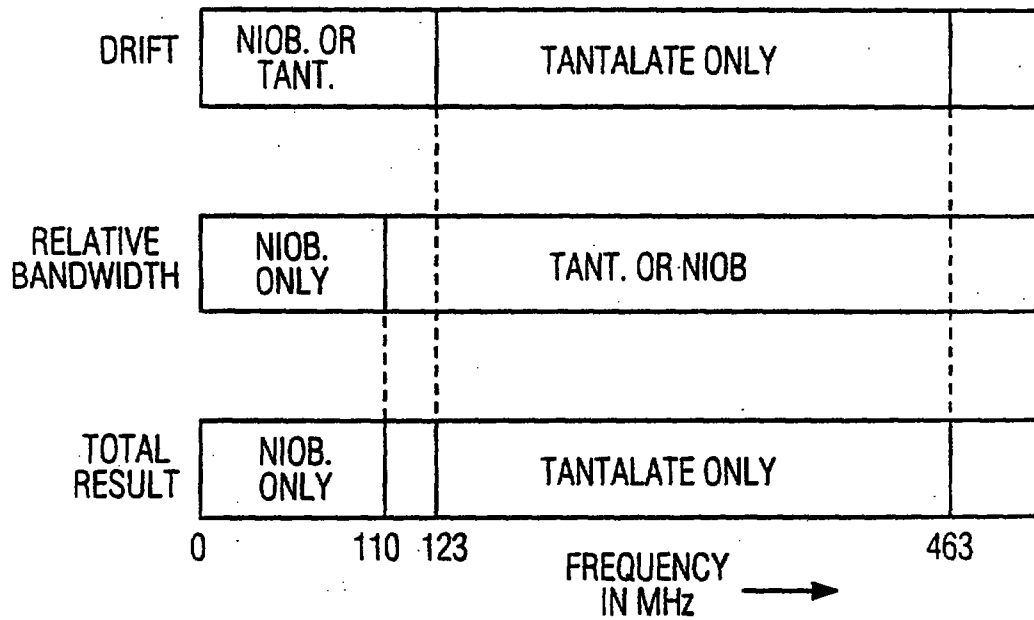


FIG. 4

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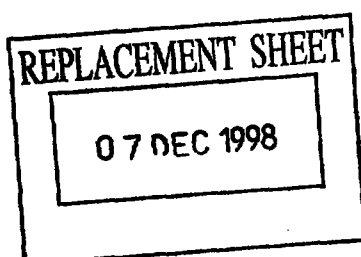
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the frequency range of RF signals produced by the block converter is accordingly somewhat smaller, e.g., between 950 and 1450 MegaHertz. As in the analog satellite television receiving systems, the RF signal corresponding to the selected channel has to be
 5 reduced in frequency to an IF frequency range for filtering and demodulation. However, the type of filtering ("symbol shaping") required in digital satellite television receiver, cannot readily be performed at the relatively high IF frequency (e.g., 479 MegaHertz) employed in an analog satellite television receiver,
 10 especially using a SAW device. As a result, a relatively expensive digital filter will be required for filtering the demodulated digital signals. Alternatively, the tuner can employ a second conversion stage to convert the relatively high frequency (e.g., 479 MegaHertz) first IF signal to a second, lower frequency (e.g., less
 15 than 100 MegaHertz) signal for filtering. However, the second conversion stage adds undesirable cost to the receiver.

It is also desirable that the tuner of the digital satellite television receiver be capable of being constructed utilizing components which are already commercially available and
 20 therefore relatively inexpensive. Specifically, in this regard it is desirable that the tuner be capable of being constructed utilizing a commercially available integrated circuit (IC) which incorporates a phase locked loop (PLL) for controlling the frequency of the local oscillator. Since a large number of tuner PLL ICs for conventional
 25 television receivers which receive and process conventional broadcast and cable television signals are widely available, it is particularly desirable that the tuner of the digital satellite television receiver be capable of being constructed utilizing such a conventional tuner PLL IC.

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According to the invention in a first aspect, there is provided a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a satellite receiving antenna and a block converter, a tuner comprising:

an RF input for receiving a plurality RF signals provided by said block converter;

a local oscillator for generating a local oscillator signal;

a mixer having a first input coupled to said RF input, a second input coupled to said local oscillator and an output at which an IF signal is produced;

a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal including intersymbol shaping;

a phase locked loop tuning control integrated circuit for controlling the frequency of said local oscillator; said phase locked loop tuning control integrated circuit being of the type which is normally utilized in conventional terrestrial broadcast and cable television receivers; and wherein

the frequency of the IF signal being selected to be in the order of the difference between the highest frequency of the RF signal received from the block converter and highest local oscillator frequency available by utilizing said phase locked loop tuning control integrated circuit.

According to the invention in a second aspect, there is provided a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a microwave satellite receiving antenna and a block converter, apparatus comprising:

an RF input for receiving said plurality of RF signals provided by said block converter;

a local oscillator in a phase locked loop tuning control

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integrated circuit for generating a local oscillator signal; a mixer having a first input coupled to said RE input, a second input coupled to said local oscillator, and an output at which an IF signal is produced; a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal; said surface acoustic wave filter being capable of symbol shaping for reducing intersymbol interference; said surface acoustic wave filter having a nominal center frequency greater than 110 MHz and significantly less than 479 MHz; and wherein the frequency of the IF signal being selected to be in the order of the difference between the highest frequency of the RF signal received from the block converter and highest local oscillator frequency available by utilizing said phase locked loop tuning control integrated circuit.

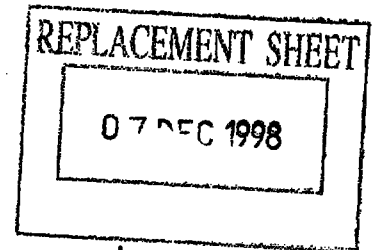
According to the invention in a third aspect, there is provided a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a satellite receiving antenna and a block converter, a tuner comprising:

an RF input for receiving a plurality RF signals provided by said block converter;

a local oscillator for generating a local oscillator signal; a mixer having a first input coupled to said RF input, a second input coupled to said local oscillator and an output at which an IF signal is produced;

a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal including intersymbol shaping; and

a phase locked loop tuning control integrated circuit for controlling the frequency of said local oscillator; said phase locked loop tuning control integrated circuit being of the type which is normally utilized in conventional



terrestrial broadcast and cable television receivers; the frequency of the IF signal being selected to be in the order of the difference between the highest frequency of the RF signal received from the block converter and highest local oscillator frequency available by utilizing said phase locked loop tuning control IC.

According to the invention in a fourth aspect, there is provided a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a satellite receiving antenna and a block converter, a tuner comprising:

an RF input for receiving a plurality RF signals provided by said block converter;

a local oscillator for generating a local oscillator signal;

a mixer having a first input coupled to said RF input, a second input coupled to said local oscillator and an output at which an IF signal is produced;

a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal including intersymbol shaping; a phase locked loop tuning control integrated circuit for controlling the frequency of said local oscillator; said phase locked loop tuning control integrated circuit being of the type which is normally utilized in conventional terrestrial broadcast and cable television receivers; and wherein:

the frequency of the IF signal is selected to be in the order of the difference between the highest frequency of said RF signals received from said block converter and the highest local oscillator frequency available by utilizing said phase locked loop tuning control integrated circuit.

According to the invention in a fifth aspect, there is provided a digital satellite television receiver for

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receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a microwave satellite receiving antenna and a block converter, apparatus comprising:

- an RF input for receiving said plurality of RF signals provided by said block converter;
- a local oscillator for generating a local oscillator signal;
- a mixer having a first input coupled to said RF input, a second input coupled to said local oscillator, and an output at which an IF signal is produced;
- a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal; said surface acoustic wave filter being capable of symbol shaping for reducing intersymbol interference; said surface acoustic wave filter having a nominal center frequency greater than 110 MHz and significantly less than 479 MHz; and wherein:

said block converter provides RF signals in a frequency range in the order of 950 to 1450 MHz and said local oscillator has a frequency range in the order of 810 to 1310 MHz.

According to the invention in a sixth aspect, there is provided a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a microwave satellite receiving antenna and a block converter, apparatus comprising:

- an RF input for receiving said plurality of RF signals provided by said block converter;
- a local oscillator in a phase locked loop for generating a local oscillator signal, said phase locked loop including a phase locked loop tuning control integrated circuit of a type which is normally utilized in conventional terrestrial broadcast and cable television receivers;
- a mixer having a first input coupled to said RF input, a second input coupled to said local oscillator, and an output

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at which an IF signal is produced;
a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal; said surface acoustic wave filter being capable of symbol shaping for reducing intersymbol interference; said surface acoustic wave filter having a nominal center frequency greater than 110 MHz and significantly less than 479 MHz; and wherein:
the frequency of the IF signal is selected to be in the order of the difference between the highest frequency of said RF signals received from said block converter and the highest local oscillator frequency available by utilizing said phase locked loop tuning control integrated circuit.



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Claims

1. In a digital satellite television receiver for receiving
and processing digital signals modulated on respective ones
of a plurality of RF signals received from an outdoor unit
5 including a satellite receiving antenna and a block
converter, a tuner comprising:
an RF input for receiving a plurality RF signals provided by
said block converter;
a local oscillator for generating a local oscillator signal;
10 a mixer having a first input coupled to said RF input, a
second input coupled to said local oscillator and an output
at which an IF signal is produced;
a surface acoustic wave filter coupled to said output of
said mixer for filtering said IF signal including
15 intersymbol shaping;
a phase locked loop tuning control integrated circuit for
controlling the frequency of said local oscillator; said
phase locked loop tuning control integrated circuit being of
the type which is normally utilized in conventional
20 terrestrial broadcast and cable television receivers; and
wherein
the frequency of the IF signal being selected to be in the
order of the difference between the highest frequency of the
RF signal received from the block converter and highest
25 local oscillator frequency available by utilizing said phase
locked loop tuning control integrated circuit.



2. In a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a microwave satellite receiving antenna and a block converter, apparatus comprising:
- 5 an RF input for receiving said plurality of RF signals provided by said block converter;
- a local oscillator in a phase locked loop tuning control integrated circuit for generating a local oscillator signal;
- 10 a mixer having a first input coupled to said RE input, a second input coupled to said local oscillator, and an output at which an IF signal is produced;
- a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal; said surface acoustic wave filter being capable of symbol shaping for
- 15 reducing intersymbol interference; said surface acoustic wave filter having a nominal center frequency greater than 110 MHz and significantly less than 479 MHz; and wherein the frequency of the IF signal being selected to be in the
- 20 order of the difference between the highest frequency of the RF signal received from the block converter and highest local oscillator frequency available by utilizing said phase locked loop tuning control integrated circuit.
- 25 3. In a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a satellite receiving antenna and a block



converter, a tuner comprising:

an RF input for receiving a plurality RF signals provided by
said block converter;

a local oscillator for generating a local oscillator signal;

5 a mixer having a first input coupled to said RF input, a
second input coupled to said local oscillator and an output
at which an IF signal is produced;

a surface acoustic wave filter coupled to said output of
said mixer for filtering said IF signal including
10 intersymbol shaping; and

a phase locked loop tuning control integrated circuit for
controlling the frequency of said local oscillator; said
phase locked loop tuning control integrated circuit being of
the type which is normally utilized in conventional
15 terrestrial broadcast and cable television receivers;

the frequency of the IF signal being selected to be in the
order of the difference between the highest frequency of the
RF signal received from the block converter and highest
local oscillator frequency available by utilizing said phase
20 locked loop tuning control IC.

4. The apparatus recited in claim 3, wherein:

said block converter provides RF signals in a frequency
range in the order of 950 to 1450 MHz and said local
25 oscillator has a frequency range in the order of 810 to 1310
MHz.



5. The apparatus recited in claim 4, wherein: said nominal frequency of said signal is 140 mHz.

6. The apparatus recited in claim 13, wherein:

5 said local oscillator is included in a phase locked loop for controlling the frequency of said local oscillator.

7. The apparatus recited in claim 6, wherein:

10 said phase locked loop includes a phase locked loop tuning control integrated circuit of the type which is normally utilized in conventional terrestrial broadcast and cable television receivers.

8. In a digital satellite television receiver for receiving
15 and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a satellite receiving antenna and a block converter, a tuner comprising:

20 an RF input for receiving a plurality RF signals provided by said block converter;

a local oscillator for generating a local oscillator signal;
a mixer having a first input coupled to said RF input, a second input coupled to said local oscillator and an output at which an IF signal is produced;

25 a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal including intersymbol shaping; a phase locked loop tuning control integrated circuit for controlling the frequency of said



local oscillator; said phase locked loop tuning control integrated circuit being of the type which is normally utilized in conventional terrestrial broadcast and cable television receivers; and wherein:

- 5 the frequency of the IF signal is selected to be in the order of the difference between the highest frequency of said RF signals received from said block converter and the highest local oscillator frequency available by utilizing said phase locked loop tuning control integrated circuit.

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9. The apparatus recited in claim 8, wherein:

said block converter provides RF signals in a frequency range in the order of 950 to 1450 mHz and said local oscillator has a frequency range in the order of 810 to 1310

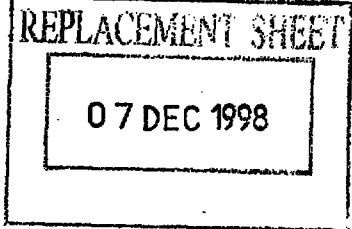
15 mHz.

10. The apparatus recited in claim 9, wherein:

said IF signal has a nominal frequency of 140 mHz.

- 20 11. In a digital satellite television receiver for receiving and processing digital signals modulated on respective ones of a plurality of RF signals received from an outdoor unit including a microwave satellite receiving antenna and a block converter, apparatus comprising:

- 25 an RF input for receiving said plurality of RF signals provided by said block converter;
a local oscillator for generating a local oscillator signal;
a mixer having a first input coupled to said RF input, a



second input coupled to said local oscillator, and an output at which an IF signal is produced;
a surface acoustic wave filter coupled to said output of said mixer for filtering said IF signal; said surface
5 acoustic wave filter being capable of symbol shaping for reducing intersymbol interference; said surface acoustic wave filter having a nominal center frequency greater than 110 MHz and significantly less than 479 MHz; and wherein:
said block converter provides RF signals in a frequency
10 range in the order of 950 to 1450 MHz and said local oscillator has a frequency range in the order of 810 to 1310 MHz.

12. The apparatus recited in claim 11, wherein:
15 said nominal center frequency of said surface acoustic wave surface filter is 140 MHz.

13. In a digital satellite television receiver for receiving and processing digital signals modulated on respective ones
20 of a plurality of RF signals received from an outdoor unit including a microwave satellite receiving antenna and a block converter, apparatus comprising:

an RF input for receiving said plurality of RF signals provided by said block converter;
25 a local oscillator in a phase locked loop for generating a local oscillator signal, said phase locked loop including a phase locked loop tuning control integrated circuit of a type which is normally utilized in conventional terrestrial



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broadcast and cable television receivers;
a mixer having a first input coupled to said RF input, a
second input coupled to said local oscillator, and an output
at which an IF signal is produced;
5 a surface acoustic wave filter coupled to said output of
said mixer for filtering said IF signal; said surface
acoustic wave filter being capable of symbol shaping for
reducing intersymbol interference; said surface acoustic
wave filter having a nominal center frequency greater than
10 110 mHz and significantly less than 479 mHz; and wherein:
the frequency of the IF signal is selected to be in the
order of the difference between the highest frequency of
said RF signals received from said block converter and the
highest local oscillator frequency available by utilizing
15 said phase locked loop tuning control integrated circuit.

14. The apparatus recited in claim 13, wherein:
said block converter provides RF signals in a frequency
range in the order of 950 to 1450 mHz and said local
20 oscillator has a frequency range in the order of 810 to 1310
mHz.

15. The apparatus recited in claim 3, wherein: said nominal
frequency of said signal is 140 mHz.

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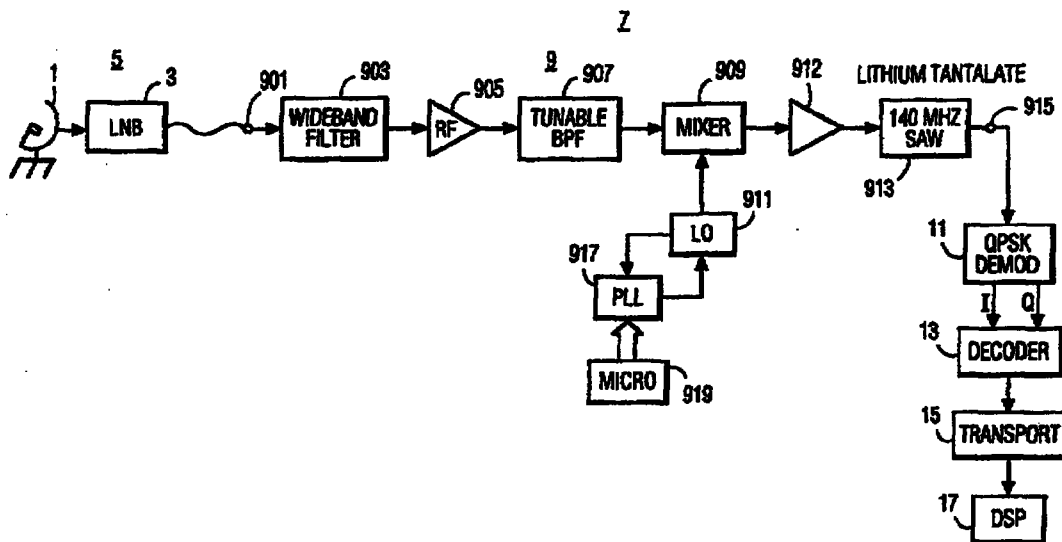


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(21) International Application Number: PCT/US96/07673 (22) International Filing Date: 28 May 1996 (28.05.96) (30) Priority Data: 08/467,097 6 June 1995 (06.06.95) US (71) Applicant: THOMSON CONSUMER ELECTRONICS, INC. [US/US]; 10330 North Meridian Street, Indianapolis, IN 46290-1024 (US). (72) Inventors: PUGEL, Michael, Anthony; 20925 Creek Road, Noblesville, IN 46060 (US); RICHTER, Kurt, Joseph; 41 Mersey Court, Carmel, IN 46031 (US). (74) Agents: TRIPOLI, Joseph, S. et al.; GE & RCA Licensing Management Operation, Inc., CN 5312, Princeton, NJ 08540 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published With international search report. With amended claims.	

(54) Title: TUNER FOR DIGITAL SATELLITE RECEIVER



(57) Abstract

A tuner (9) for a digital satellite television receiver comprises a single conversion stage which produces an IF signal at a low enough frequency to permit a SAW filter (913) to be used to perform symbol shaping as well as the normal IF filtering function. The local oscillator (911) is controlled by a phase locked loop tuning control IC normally used to control the local oscillator (911) of a tuner of a conventional broadcast or cable television receiver. In an exemplary embodiment for tuning RF signals provided by a block converter (3) in the 950 to 1450 MHz frequency range, the IF has a center frequency of 140 MHz.

* (Referred to in PCT Gazette No. 29/1997, Section II)