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Wyszynski

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(54) **FULLY INTEGRATED TERRESTRIAL TV TUNER ARCHITECTURE**

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(58) **Field of Classification Search** 348/725, 348/731, 733; 455/189, 1, 296, 334, 339; 327/557, 564; *H04N 5/44; H04B 1/16*
See application file for complete search history.

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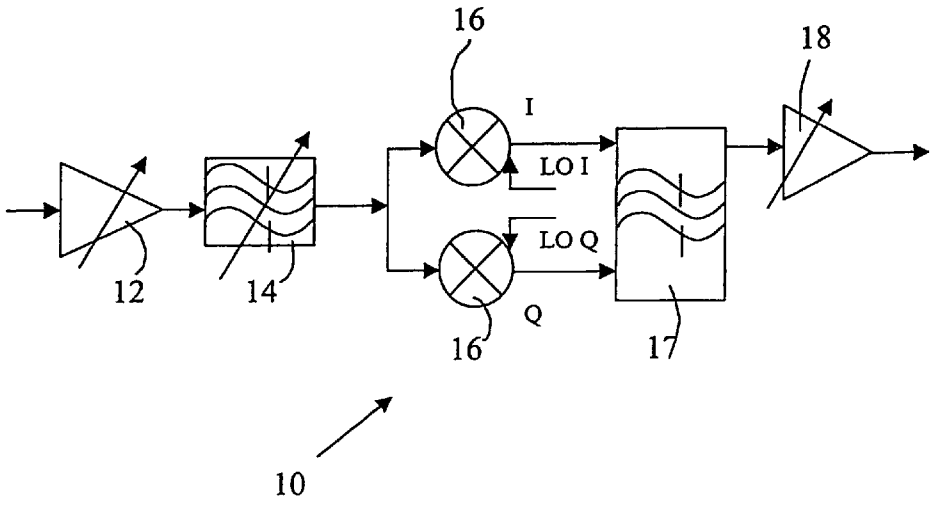
(57) **ABSTRACT**

A TV tuner consisting of a least one low-noise amplifier, one mixer and one variable-gain amplifier plus two band-pass filters, the first of which is placed after low-noise amplifier and before the mixer, and the second of which is placed after mixer and before variable-gain amplifier. The filters are on-chip active devices equipped with on-chip frequency- and Q-tuning systems. The first band-pass filter is a real filter, such that its frequency response is symmetrical for positive and negative frequencies. The second band-pass filter is a complex filter, such that its frequency response has transmission for positive frequencies, but blocks negative frequencies. The low-noise amplifier includes gain control. The mixer is a complex-mixer consisting of two identical mixers driven by two local oscillator signals in quadrature.

14 Claims, 4 Drawing Sheets



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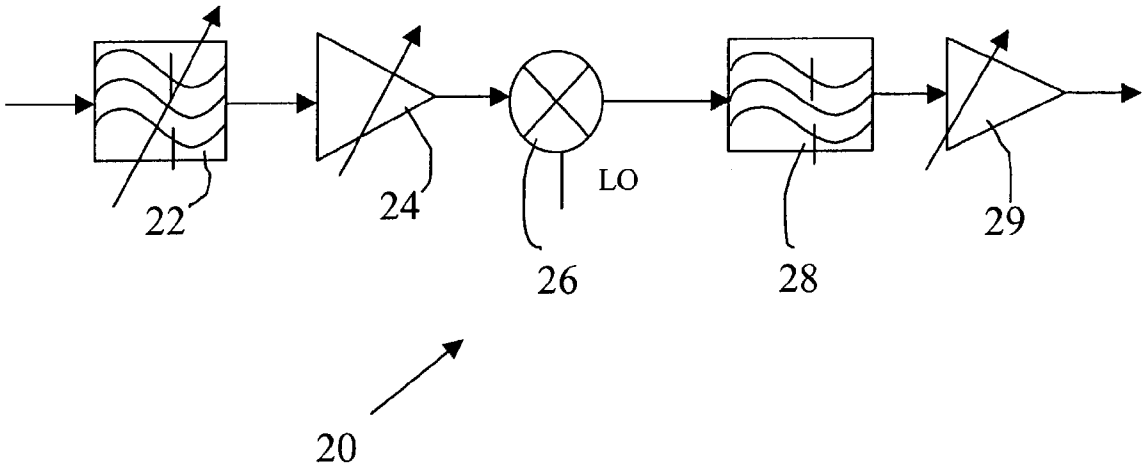

Figure 1

Prior Art

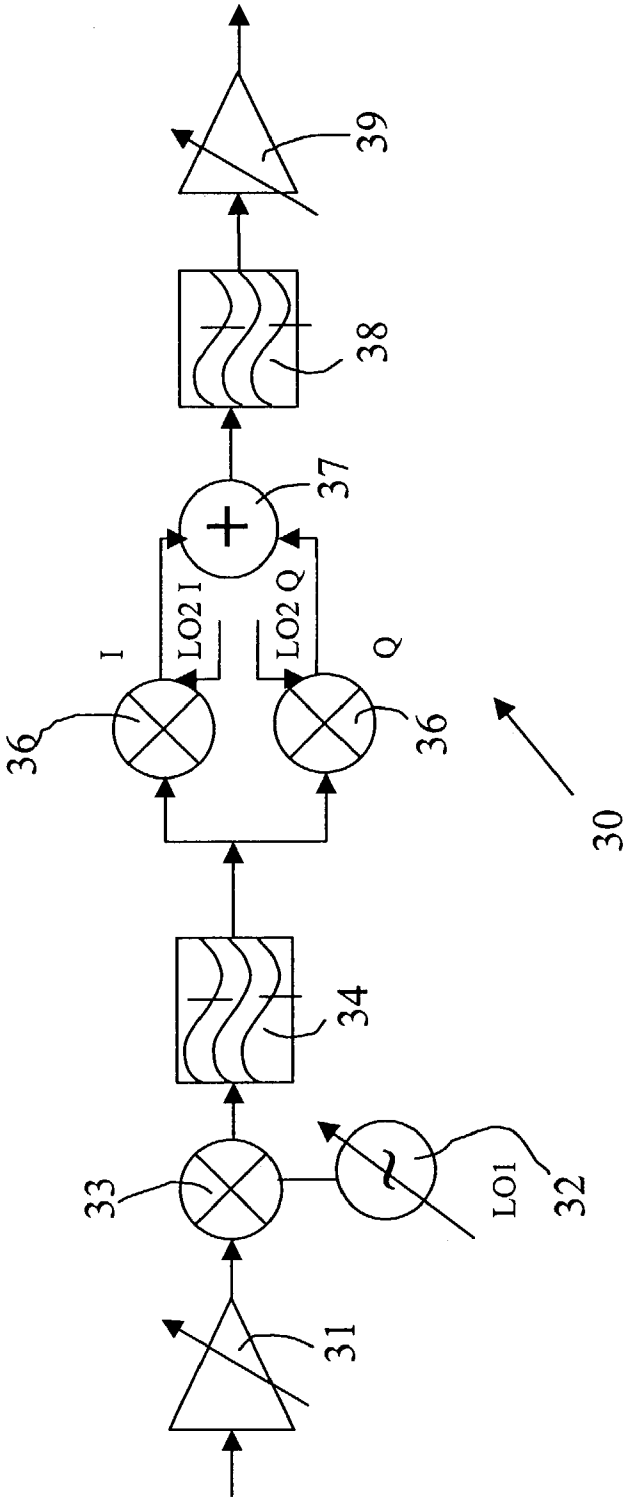

Figure 2
Prior Art

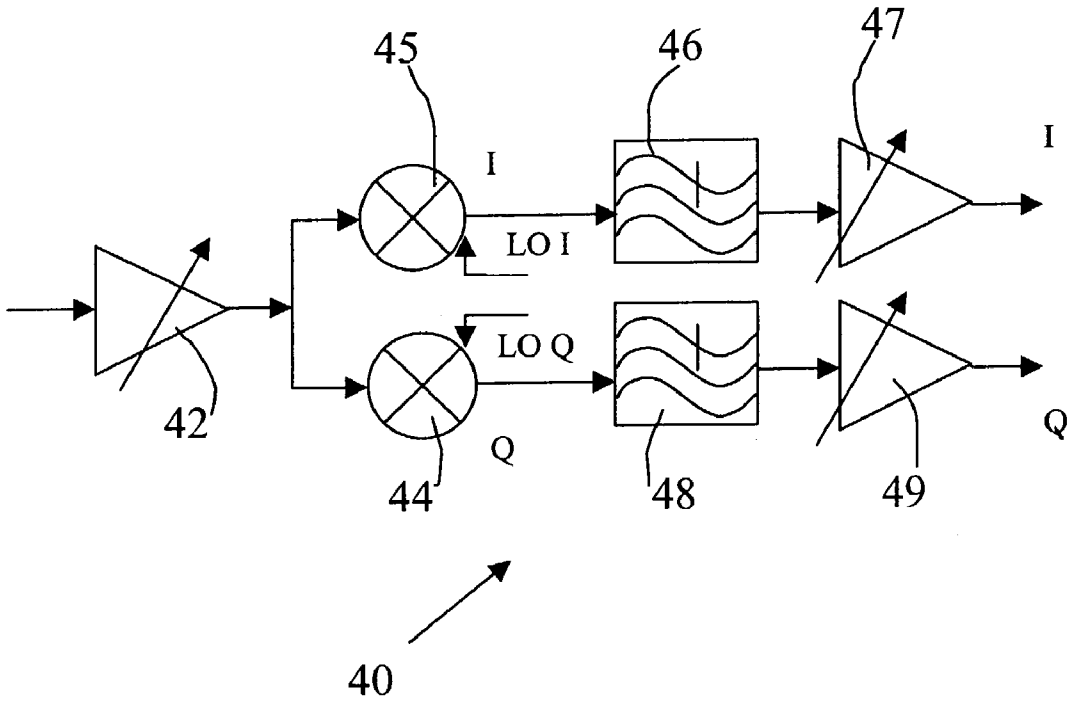

Figure 3

Prior Art

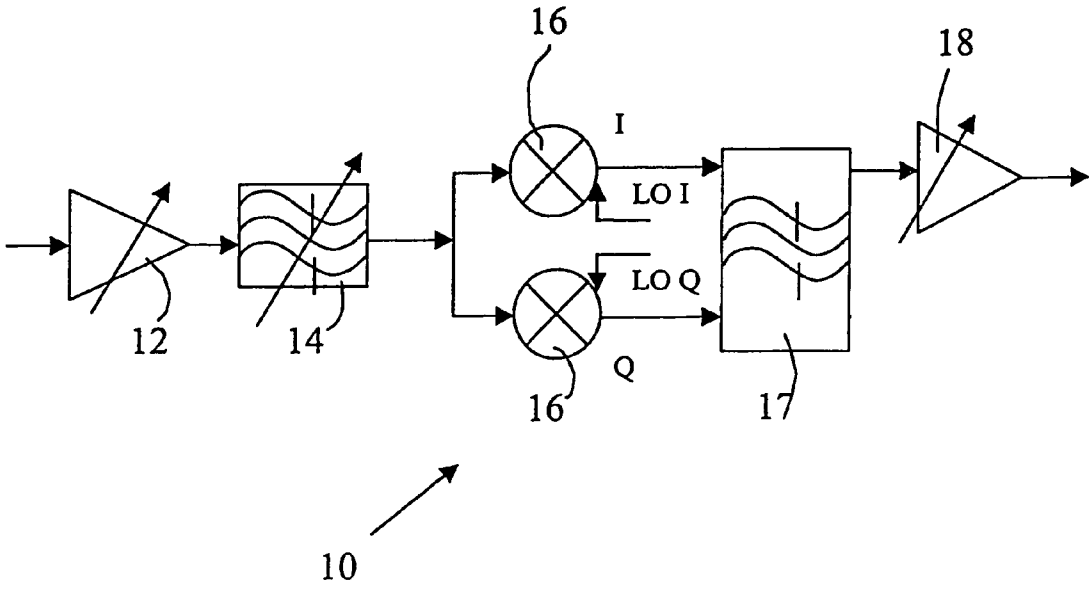

Figure 4

FULLY INTEGRATED TERRESTRIAL TV TUNER ARCHITECTURE

TECHNICAL FIELD OF THE INVENTION

The present invention relates to TV receivers, or tuners such as those utilized for terrestrial (off-the-air) broadcast reception, and more particularly to a fully integrated implementation of the terrestrial TV tuner on a silicon chip.

BACKGROUND OF THE INVENTION

Currently, terrestrial tuners are built as hybrid devices using limited number of small ICs, metal shield can and external discrete components such as manually tuned coils and varactors. Significant progress has been made in integration of cable tuners. Most of these devices are integrated on

presented in FIG. **2**. It consists of an high-frequency image reject low-pass filter (not shown in FIG. **3** for simplicity) followed by the LNA circuit **31** with its output connected to the first up-conversion mixer **33** which receives an input from a local oscillator **32**. The output of the mixer **33** is brought off-chip to a ceramic BPF **34** with the center frequency in the range of 1000-1200 MHz with bandwidth of about 30 MHz. Next the signal is brought back on-chip to the input of a complex down-conversion mixer **36**. The output of the mixer is summed by the poly-phase filter/summer **37**, which cancels the undesired image on the second mixer and passed again off-chip to a standard TV IF SAW filter **38** at 43.75 MHz. After passing the external IF filter the signal is brought back on-chip to the input of the variable gain amplifier VGA **39**. There are two main problems with this architecture. First, it requires two external filters and several discrete components that complicate the board design and increase the cost of

FIG. **3** is a block diagram of a prior art integrated DBS tuner; and

FIG. **4** is a block diagram of the present fully-integrated terrestrial TV tuner.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the FIG. **4**, the present terrestrial tuner system is illustrated, and is generally identified by the numeral **10**. The TV signal from the antenna enters the input of the low-noise amplifier (LNA) circuit **12**, the output of which is connected to a tunable on-chip RF bandpass filter (RFBPF) circuit **14**. The output of RFBPF circuit **14** is then connected to the two inputs of the complex mixer circuit **16**, which consists of two identical mixers fed by identical input signals and two LO signals shifted by 90 degrees (LO I and LO Q). The complex mixer has two outputs I and Q. They enter two inputs of the complex IF bandpass filter (IFBPF) circuit **17**. The I and Q outputs of the complex IFBPF circuit **17** are connected to the input of a variable gain amplifier (VGA) circuit **18**.

LNA circuit **12** is required to have a low noise figure, very high linearity and ability of 25-30 dB gain control. RFBPF circuit **14** is realized as a tunable actively Q-enhanced passive LC filter demonstrating gain greater than 0 dB to help improve its noise figure and a good linearity. The complex mixer circuit **16** has a good linearity and a decent noise figure. It is followed by a complex active IFBPF circuit **17** and finally by VGA circuit **18** with gain control range of 50-55 dB and a good linearity.

Since the standard TV IF is at 44 MHz the image is positioned always 88 MHz away from the passband of RFBPF circuit **14**. This allows the RFBPF circuit **14** to attenuate the signal at image frequency by at least 10 dB for both VHF and UHF bands.

If the low-IF instead of the standard TV IF is used the image attenuation by the RFBPF circuit **14** will be negligible. However, the two other elements: the complex mixer circuit **16** and the complex IFBPF circuit **17** will provide required 65 dB of image rejection.

Because of its simple single-conversion architecture and the inclusion of the prefiltering the presented TV tuner **10** demonstrates excellent linearity. It is able to process the input signals up to about 0 dBm in 75 Ohm environment. Its overall noise performance also exceeds that of specs: its noise figure is below 6 dB.

As an advantage over terrestrial hybrid designs the present tuner achieves a substantial cost reduction by elimination of the factory tuning, the metal shield can and the module filled with discrete components. Overall the estimated component and labor savings for the TV or VCR manufacturer should be in the range of approximately $2 per unit. The present tuner does not use any external components except for power supplies blocking caps and possibly the synthesizer loop filter.

As additional advantage over terrestrial hybrid and the existing integrated cable designs, since all filtering is performed on-chip and it is assisted with automatic tuning circuitry, no factory trim is required to meet the specs. This additionally simplifies the hardware manufacturing and reduces its overall unit cost by at least $2 through elimination of two ceramic or SAW filters and other discrete components needed for a typical integrated cable tuner.

Because of its simple single-conversion architecture including the prefiltering and since all filtering is performed on-chip the tuner power consumption is reduced to 300-500 mW for the standard home applications with possibility of only 100-200 mW for mobile applications. This is 3-10 times lower compared to present integrated cable turners.

With only minor specification modifications the presented tuner technology is applicable both for terrestrial analog applications and digital cable applications.

Because of its small feature size, low power consumption and its affordable pricing, the presented tuner lends itself to multiple tuner applications in contemporary home appliances and emerging portable and mobile applications.

For the cost purpose the targeted technology is a short-channel CMOS, but any modern silicon CMOS, BiCMOS, or bipolar technology process may be used to implemented the presented tuner.

I claim:

1. A tuner system for television signal reception comprising:

a low-noise amplifier for receiving a television signal, said low-noise amplifier having a gain and generating an output signal;

a tunable real band-pass filter, having a symmetrical frequency response for positive and negative frequencies, for directly receiving said output signal of said low-noise amplifier, and for generating an output signal;

a complex mixer including of at least two mixers for receiving said output signal of said real band-pass filter and for generating at least one output signal;

a continuous time complex analog band-pass filter, having a non-symmetrical frequency response for positive and negative frequencies, for directly receiving said at least one output signal of said mixer and generating for at least one output signal; and

a variable gain amplifier for receiving said at least one output signal of said complex band-pass filter.

2. The tuner system of claim **1** wherein said variable gain amplifier includes:

first and second variable-gain amplifiers for receiving first and second output signals from said complex band-pass filter.

3. The tuner system of claim **1** wherein said filters, amplifiers and mixer are fabricated in monolithic technology selected from the group consisting of silicon CMOS, BiCMOS and bipolar processes.

4. The tuner system of claim **1** wherein:

said real band-pass filter is an on-chip active device; and

said complex band-pass filter is an on-chip active device.

5. The tuner system of claim **1** and further including:

an on-chip frequency-tuning system for the said real band-pass filter;

an on-chip Q-tuning system for the said real band-pass filter;

an on-chip frequency-tuning system for the said complex filter; and

an on-chip Q-tuning system for the said complex filter.

6. The tuner system of claim **1** further including:

a frequency-tuning system for at least one of said filters for adjusting a center-frequency with respect to a reference frequency; and

a Q-tuning system for at least one of said filters for adjusting a magnitude, and thereby a filter Q-factor, with respect to a reference amplitude.

7. The tuner system of claim **1** wherein:

said real band-pass filter is tunable by changing its center frequency and its bandwidth; and

said complex band-pass filter is tunable by changing its center frequency and its bandwidth.

8. The tuner system of claim 1 wherein:

said real band-pass filter is selected from the group consisting of Q-enhanced LC design and gm-C design; and

a complex band-pass filter is selected from the group consisting of an active R-C design, MOSFET-C design, and gm-C design.

9. The tuner system of claim 1 and further including:

means for controlling said gain of said low-noise amplifier.

10. The tuner for the system of claim 1 where said mixer includes:

first and second mixers driven by local oscillator signals in quadrature.

11. The tuner system of claim 1 and further including a local oscillator operating at a higher frequency than the input TV carrier frequency, or at high-side injection.

12. The tuner system of claim 1 and further including a local oscillator operating at a lower frequency than the input TV carrier frequency, or at low-side injection.

13. The tuner system of claim 1 and further including a local oscillator operating at a frequency that down-converts the input TV carrier frequency to one of a standard IF TV frequency.

14. The tuner system of claim 1 and further including a local oscillator operating at a frequency that down-converts the input TV carrier frequency to a low-IF frequency that is distinctly lower than any standard TV IF frequency.

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