Description

Filter circuit

The present invention refers to filter circuits, especially to switchable filter circuits.

Modern broadcast receiving devices should be able to receive video or audio signals of different transmission standards. Such devices usually comprise filters in filter circuits to separate wanted from unwanted signals. These filters should be producible in a cost-efficient manner, lightweight and have small spatial dimensions. Despite this trend towards miniaturization, the selectivity of respective filter circuits should satisfy demanded specifications. Further, respective filter circuits should be commensurate with standard packages. Especially the number of electrical components should be reduced in order to obtain filter circuits that can be integrated in standard packages.

Filter circuits can utilize filters working with acoustic waves such as SAW (surface acoustic waves). Components working with SAW comprise electrode fingers being arranged on a piezoelectric substrate.

It is an object of the present invention to provide a multi-standard filter circuit comprising a reduced number of piezoelectric substrates and a reduced area consumption on piezoelectric substrates.

For that, a filter circuit according to claim 1 is provided. Dependent claims refer to preferred embodiments of the invention.

The invention refers to a filter circuit comprising a first SAW filter and a double hump SAW filter. The first SAW filter and the double hump filter are electrically connected in parallel.

A double hump filter has two passbands in which signals are transmitted. For that, the double hump SAW filter comprises filter structures within a common acoustic track on a piezoelectric substrate. The respective first and the respective second passband of the double hump SAW filter can serve for receiving signals of different transmission standards. Thus, a filter circuit is obtained that allows multi-standard operation and that is producible in a cost-efficient manner, lightweight and has small spatial dimensions because the double hump SAW filter combines the functionality of two distinct filters within a common acoustic track. Such a filter circuit can thus be integrated in standard packages because the number of components and the area of a piezoelectric substrate are reduced.

As the inventors have found, the selectivity of such a filter - although two filter functions are combined within the same acoustic track - fulfills the demanded specifications.

In one embodiment, the filter circuit comprises a common piezoelectric substrate. The first SAW filter and the double hump SAW filter are arranged on the common piezoelectric substrate.

Such a filter circuit integrates three filter functions - one of the first SAW filter and two of the double hump SAW filter - on a common piezoelectric substrate. As a result, the spatial dimensions are further reduced and the number of compo-

nents such as piezoelectric substrates is reduced. The electrode structures of the first SAW filter and of the double hump SAW filter can be created during the same steps of manufacturing. Accordingly, production costs are reduced and the ability to be integrated within conventional packaging technologies is enhanced.

In one embodiment, the piezoelectric substrate carrying the filter structures of the first SAW filter and the double hump SAW filter is encased in an SMT package (SMT = Surface Mount Technology).

The SMT package can be a conventional package to be mounted on a carrier substrate together with other components like switching components. Especially, the SMT package can be a DIP18D package. Such a package comprises a duroplast material, has a weight of approximately 0.5 g and has a standard IC outline package of small dimensions. Such an SMT package is compatible to the directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC (RoHS).

In one embodiment, the first SAW filter and the double hump SAW filter are dedicated to analog IF signals (IF = Intermediate Frequency).

Conventional broadcast receiving devices comprise analog tuners, filter circuits and IF demodulation ICs. The filter circuits are electrically connected between the analog tuner and the IF demodulation IC. The analog tuner generally provides IF signals which have to be processed by filter circuits in order to remove unwanted frequency components. The IF demodulation IC obtains an IF signal from the filter circuits and

demodulates these IF modulated signals for further processing.

The present filter circuit is compatible to IF signals. Thus, according filter circuits can replace conventional filter circuits, i. e. bigger and more expensive filter circuits, without the need for additional modulation or demodulation circuits to obtain a modern multi-standard broadcast receiving device.

Further, the present filter circuit requires less filter elements or components to realize a modern multi-standard broadcast receiving device.

In one embodiment, the first SAW filter is dedicated to video signals and the double hump SAW filter is dedicated to audio signals. Such a filter circuit can be utilized in a multi-standard TV receiving device because it is able to process video signals in the first SAW filter and multi-standard audio signals in the double hump SAW filter.

In one embodiment, the double hump SAW filter is a transversal SAW filter.

In a transversal SAW filter, filter structures such as interdigitated electrode fingers are arranged within a single acoustic track on a piezoelectric substrate. Transversal SAW filters can provide two distinct passbands, i.e. two frequency ranges of high transmittivity (i.e. of a low insertion loss) which are separated by a frequency range of a low transmittivity (i.e. of a high insertion loss). Transversal filters, therefore, comprise input and output interdigital transducers. The input transducers can be electrically con-

nected to a conventional analog tuner and the output transducers can be electrically connected to conventional IF demodulation ICs. The area consumption on a piezoelectric material on which the filter structures are arranged is reduced compared to the situation where two distinct filter structures are arranged in different acoustic tracks on the same piezoelectric substrate or even on different piezoelectric substrates.

Despite the high degree of integration, the filter circuit shows the sensitivity required by current specifications.

In one embodiment, the double hump SAW filter comprises a first passband having a center frequency of 32.95 MHz and a second passband having a center frequency of 40.45 MHz. These frequency ranges are IF frequency ranges that are compatible with conventional analog tuners and conventional IF demodulation ICs.

The first passband can comprise frequencies between 32.45 and 33.45 MHz. The second passband can comprise frequencies between 39.8 and 40.45 MHz.

In one embodiment, the filter circuit comprises a switching circuit that is electrically connected to the double hump SAW filter. The switching circuit can be electrically connected between an analog tuner and the filter circuit's double hump SAW filter. Then, the switching circuit can be utilized to select the passband according to a transmission standard to be received. For that, the switching circuit is connectable to input transducers of the double hump SAW filter.

In one embodiment, the switching circuit provides two parallel signal paths, each of which comprises a trap circuit.

When signals such as audio signals of a first passband should be received, then the switching circuit can provide a signal path in which a trap circuit eliminating or damping signals of the respective other passband and the double hump SAW filter are electrically connected in series. Accordingly, when signals of the respective other signal passband shall be received, then a trap circuit eliminating or damping signals of the first passband and the double hump SAW filter can be electrically connected in series.

Therefore, in one embodiment, the double hump SAW filter comprises two signal inputs and each of the signal inputs is electrically connected to a different signal path of the switching circuit.

With such a configuration of the switching circuit and the double hump SAW filter, a good sensitivity of the filter circuit is obtained although the spatial dimensions of the filter circuit, especially of the SAW filter structures, are reduced.

In one embodiment, the filter circuit is dedicated to filtering TV signals. I.e. audio signals and video can be received simultaneously and without crosstalk because the video signals can be received via the first SAW filter and the audio signals - which can belong to different transmission standards - can be received via the double hump SAW filter.

In one embodiment, the double hump SAW filter comprises a first passband being dedicated to receiving audio signals of

a B/G, D/K, or I and L standard. A second passband can be dedicated to receiving audio signals of the L' standard.

The present invention will become fully understood from the detailed description given hereinbelow and the accompanying schematic drawings. In the drawings:

FIG. 1 shows the basic concept of the present invention,

FIG. 2 shows a sagittal cross-section on a piezoelectric substrate,

FIG. 3 shows an SMT-compatible package,

FIG. 4 shows a filter circuit comprising a switching circuit,

FIG. 5a shows a switching circuit,

FIG. 5b shows a switching circuit,

FIG. 6 shows a transversal filter comprising input transducers and output transducers,

FIG. 7 shows an equivalent circuit diagram of a switching circuit,

FIG. 8 shows the frequency dependent insertion loss of the first SAW filter,

FIG. 9 shows the frequency dependent insertion loss of the double hump SAW filter.

FIG. 1 shows an embodiment of a filter circuit FC comprising a first SAW filter F1 and a double hump SAW filter DHF. The first SAW filter F1 and the double hump SAW filter DHF are electrically connected in parallel. The first SAW filter F1 can process video IF signals and the double hump SAW filter DHF can process audio IF signals of different transmission standards in different passbands.

FIG. 2 shows a schematic view onto a piezoelectric substrate PSU on which a first acoustic track AT1 and a second acoustic track AT2 are arranged. The first acoustic track AT1 comprises the first SAW filter F1. The second acoustic track AT2 comprises the double hump SAW filter DHF and its metallization structures (not shown in the figure) comprising input and output transducers.

FIG. 3 shows a package that is compatible to SMT (Surface Mounting Technology) having a length l and a width w. The length l can be 13.7 mm and the width w can be 4.8 mm. The width including the electrical connections can be 7.15 mm. Especially, the SMT compatible package can be a DIP18D package.

FIG. 4 shows an embodiment of the filter circuit FC comprising a switching circuit SC. The double hump SAW filter DHF is electrically connected in parallel to the first SAW filter F1. The switching circuit SC is electrically connected in series with the double hump SAW filter DHF and in parallel to the first SAW filter F1.

FIG. 5a shows more details of an embodiment of the switching circuit SC of FIG. 4. The switching circuit SC comprises a signal input SI and two switchable signal outputs SO1, SO2.

Further, the switching circuit SC comprises a first trap circuit TC1 and a second trap circuit TC2. The trap circuits TC1 and TC2 are electrically connected in parallel signal paths. The first trap circuit TC1 is electrically connected to a first signal output SO1 and the second trap circuit TC2 is electrically connected to a second signal output SO2. The signal outputs SO1, SO2 electrically connect the switching circuit SC with respective inputs of the double hump SAW filter DHF.

FIG. 5b shows a preferred alternative embodiment of the switching circuit of FIG. 5a. The first trap circuit TC1 and the second trap circuit TC2 are electrically connected at each other at the output side of the switching circuit. Both trap circuits are, thus, electrically connected to a common signal output SO.

The switching circuit SC can be in two switching states. In a first switching state - as shown in FIG. 5 - the signal input SI is electrically connected to the first trap circuit TC1. However, the switching circuit could also be in a second switching state in which the signal input SI is electrically separated from the first trap circuit TC1 and electrically connected to the second trap circuit TC2. Providing trap circuits TC1, TC2 within the switching circuit SC enables to eliminate propagating signals of the respective other, unused passband of the double hump SAW filter when a first passband of the double hump SAW filter is in use. Thus, the selectivity of the filter circuit is obtained to fulfill required specifications.

FIG. 6 shows an embodiment of the double hump SAW filter being a transversal filter TF. The transversal filter TF is ar-

ranged within the second acoustic track AT2 of the double hump SAW filter. The second acoustic track AT1 is arranged on the piezoelectric substrate PSU. The transversal filter TF comprises an input transducer IT and an output transducer OT arranged next to the input transducer IT. The piezoelectric substrate PSU thus comprises highly integrated filter circuits because SAW filter structures providing three passbands are arranged within two acoustic tracks on a single piezoelectric substrate. Thus, filter circuits in corresponding filter components can be assembled in a cost-efficient manner and filter components having small spatial dimensions can be obtained.

FIG. 7 shows an equivalent circuit diagram of the switching circuit SC. The switching circuit SC comprises a signal input SI and a common signal output SO that may be used to deliver signals in the frequency range of the first passband or of the second passband. Further, the switching circuit SC comprises a toggle port TP and a voltage supply port VCC. Between the signal input SI and the common signal output SO shown in the upper part of FIG. 7, a first capacitive element C1, a second resistive element R2, a second capacitive element C2 and a second inductive element L2 are electrically connected in series. A third capacitive element C3 is electrically connected in parallel to the second inductive element L2. A first resistive element R1 and a third resistive element R3 electrically connect the electrodes of a second resistive element R2 to ground. The second capacitive element C2 is electrically connected to the signal output SO2 shown in the lower part of FIG. 7. A first inductive element L1 and a sixth capacitive element C6 are electrically connected in series between the common signal output SO and ground. A fourth capacitive element C4 is electrically connected be-

tween the voltage supply port VCC and ground. A sixth resistive element R6 and a transistor T1 are electrically connected in series between the voltage supply port VCC and ground. A fourth resistive element R4 is electrically connected between the base port of transistor T1 and ground. The emitter port of transistor T1 is electrically connected to ground. The sixth resistive element R6 and the fifth capacitive element C5 are electrically connected to the collector port of transistor T1. A fifth resistive element R5 is electrically connected between the toggle port TP and the base port of transistor T1.

Thus, the switching circuit SC comprises transistor T1 as the only active switching component. The residual switching components are passive components only. By toggling a signal voltage which can be either 0 V or 12 V, the switching circuit can be configured to transmit either signals of the first passband from the signal input SI to the common signal output SO or signals of the second passband from the signal input SI to the common signal output SO.

The signal input SI can be adapted to match an impedance of 50 Ω.

The first capacitive element can have a capacity of 10 nF.
The second capacitive element can have a capacity of 10 nF.
The third capacitive element can have a capacity of 68 pF.
The fourth capacitive element can have a capacity of 10 nF.
The fifth capacitive element can have a capacity of 8.2 pF.
The sixth capacitive element can have a capacity of 1.5 pF.

The first resistive element can have a resistance of 100 Ω.
The second resistive element can have a resistance of 68 Ω.

The third resistive element can have a resistance of 100 Ω. The sixth resistive element can have a resistance of 2.2 kΩ. The fifth resistive element can have a resistance of 5.6 kΩ. The fourth resistive element can have a resistance of 5.6 kΩ.

The first inductive element can have an inductivity of 2.2 µH.

The second inductive element can have an inductance of 0.27 µH.

Such a switching circuit SC provides a good selectivity.

FIG. 8 shows the insertion loss in dB of an according first SAW filter provided for video signals.

FIG. 9 shows the insertion loss in dB of a transversal double hump SAW filter provided for audio signals according to the invention.

The basic concept of the present invention does not depend on technological details of switching elements or the SAW filter elements. Variations of the switching circuit comprising different means for switching or comprising further active or passive switching elements are also possible. Further, additional filter elements such as additional SAW filters that are electrically connected in parallel or in series to one of the present SAW filters are also possible. The invention is not restricted by the embodiments described above or by the accompanying figures.

List of reference signs:

AT1, AT2:	first, second acoustic track
C1, C2, C3, C4, C5, C6:	capacitive element
DHF:	double hump SAW filter
f:	frequency
F1:	first SAW filter
FC:	filter circuit
GND:	ground
IT, OT:	input, output transducer
l:	length
L1, L2:	inductive element
PSU:	piezoelectric substrate
R1, R2, R3, R4, R5, R6:	resistive element
SC:	switching circuit
SI:	signal input
SMTP:	SMT-compatible package
SO, SO1, SO2:	signal output
T1:	transistor
TC1, TC2:	first, second trap circuit
TF:	transversal SAW filter
w:	width

Claims:

1. A filter circuit (FC), comprising
   - a first SAW filter (F1) , a double hump SAW filter (DHF) and a switching circuit (SC) being electrically connected to the double hump SAW filter (DHF),
   where
   - the first SAW filter (F1) and the double hump filter (DHF) are electrically connected in parallel and
   - the switching circuit (SC) provides two parallel signal paths, each of which comprising a trap circuit (TC1, TC2).

2. The filter circuit of the previous claim, further comprising a common piezoelectric substrate (PSU), where the first SAW filter (F1) and the double hump SAW filter (DHF) are arranged on the piezoelectric substrate (PSU).

3. The filter circuit of the previous claim, where piezoelectric substrate (PSU) is encased in a SMT package (SMTP).

4. The filter circuit of the previous claim, where the SMT package (SMTP) is a DIP18D package.

5. The filter circuit of one of the previous claims, where the first SAW filter (F1) and the double hump SAW filter (DHF) are dedicated to analogue IF Signals.

6. The filter circuit of one of the previous claims, where the first SAW filter (F1) is dedicated to video signals and the double hump SAW filter (DHF) is dedicated to audio signals.

7. The filter circuit of one of the previous claims, where the double hump SAW filter (F1) is a transversal SAW filter (TF).

8. The filter circuit of one of the previous claims, where the double hump SAW filter (DHF) comprises a first passband having a center frequency of 32.95 MHz, and a second passband having a center frequency of 40.45 MHz.

9. The filter circuit of one of the previous claims, where
- the double hump SAW filter (DHF) comprises two signal inputs, and
- each of the signal inputs is electrically connected to a different signal path of the switching circuit.

10. The filter circuit of one of the previous claims, being dedicated to filtering TV signals.

11. The filter circuit of one of the previous claims, where the double hump SAW filter (DHF) comprises
- a first passband being dedicated to receiving audio signals of the B/G, D/K, or I&L standard, and
- a second passband being dedicated to receiving audio signals of the L' standard.