(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 May 2012 (03.05.2012)

PCT

(10) International Publication Number
WO 2012/055439 A1

(51) International Patent Classification:
H03H 9/72 (2006.01) *H04B 1/18* (2006.01)
H04N 5/46 (2006.01) *H04B 1/00* (2006.01)

(21) International Application Number:
PCT/EP2010/066383

(22) International Filing Date:
28 October 2010 (28.10.2010)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2012/055439 A1

(54) Title: SWITCHABLE FILTER

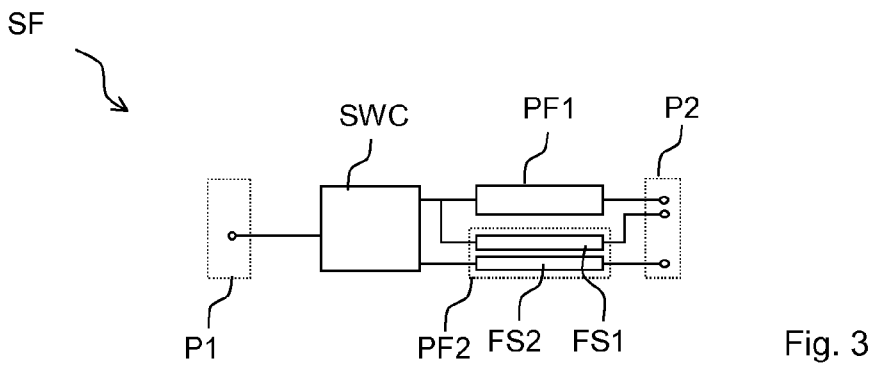

Fig. 3

(57) Abstract: A switchable filter for different transmission standards that is produceable in a cost-efficient manner and that has reduced cross-talk between different signal paths is provided. The switchable filter comprises a first partial filter, a second partial filter and a switch circuit that can switch between a first state and a second state. In the first state, the first partial filter is electrically connected to a first port. In the second state, the first partial filter is electrically separated from the first port.

Description

Switchable filter

The present invention relates to switchable filters.

Modern broadcast receiving devices should be able to receive video or audio signals of different transmission standards, e. g. such as DVB-T (Digital Video Broadcasting Terrestrial) or DVB-C (Digital Video Broadcasting Cable).

Respective filters for such devices should be produceable in a cost-efficient manner. Further, especially in mobile broadcast receiving devices, respective filters should be lightweight and should have small spatial dimensions.

Miniaturization of filters for different transmission standards in general leads to increased cross-talk between the signal lines of the different standards. Thus, the noise level within the signal lines is increased.

It is, thus, an object of the present invention to provide filters that allow reception of different transmission standards, that are produceable in a cost-efficient manner, that are lightweight, that have small spatial dimensions, and that have a reduced cross-talk between different signal paths, and, as a result of reduced cross-talk, that have a reduced noise level.

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

The invention refers to a switchable filter that comprises a first partial filter and a second partial filter. The switchable filter further comprises a first port and a second port and a switch circuit having a control port. The switch circuit can switch between a first state and a second state. The first partial filter is electrically connected between the switch circuit and the second port. The second partial filter is electrically connected between the switch circuit and the second port. The second partial filter is electrically connected in parallel to the first partial filter. The switch circuit is electrically connected to the first port, to the first partial filter, and to the second partial filter. A control signal applied to the control port determines the state of the switch circuit. In the first state, the first partial filter is electrically connected to the first port. In the second state, the first partial filter is electrically separated from the first port.

The first partial filter can comprise a first bandpass filter having a first center frequency and a first bandwidth.

Such a switchable filter, thus, has a first partial filter that may be dedicated to a first transmission standard and a second partial filter that may be dedicated to a second transmission standard. The switch circuit of the switchable filter has two switching states where each switching state can be dedicated to a different transmission standard. In other words, by selecting the switching state of the switch circuit, the characteristic of the switchable filter can be altered to provide filter characteristics that are specific for different transmission standards.

The first partial filter is electrically separated from the first port in the second state. Such a configuration allows to decouple the first partial filter from a signal path of the switchable filter. As a result, cross-talk between the first partial filter and the second partial filter is reduced and the noise level of signals passing through the second partial filter is reduced.

The second partial filter may be electrically connected to the first and to the second port in the first state. However, the second partial filter may be separated from the first port or from the second port.

The switchable filter can be dedicated to the RF (radio frequency) range or to an IF (intermediate frequency) range.

The phrase "electrically separated" refers to the switching state of the switch circuit. Especially switch circuits comprising semiconductor switches can deactivate a electrical connection while the physical contact of respective signal lines is still maintained.

As a result of the above arrangement, both partial filters realize alternative signal paths for a signal. Thus, multi mode communication with reduced crosstalk is provided.

In one embodiment, the first partial filter and the second partial filter are SAW (Surface Acoustic Wave) filters.

Surface acoustic wave filters comprise interdigitated electrode structures that are arranged on a piezoelectric substrate. Surface acoustic wave filters have good separation characteristics, i.e. the ratio between the power of transmit

signals in a passband and the transmitted unwanted signals outside the passband is sufficiently good for modern applications.

SAW filters are well suited as switchable filters. Such SAW filters are compatible with specifications, i.e. bandwidth and center frequencies of passbands, of broadcast transmission standards.

In one exemplary embodiment, the second partial filter is an SAW filter and comprises first filter structures and second filter structures. Both filter structures are arranged within the same acoustic track. The first filter structures can be a SAW filter having a second passband with a second center frequency and a second bandwidth. The second filter structures can also be an SAW bandpass filter having a third center frequency and a third bandwidth.

By using a partial filter having more than one filter structures the number of acoustic tracks can be reduced resulting in smaller and cheaper filters.

Dual SAW filters for broadcast standards are, e. g., known from US 5,867,075.

Arranging the second partial filter having the first filter structures and the second filter structures within the same acoustic track on a piezoelectric substrate results in a switchable filter with reduced spatial dimensions. As a result, the area on expensive piezoelectric substrates is smaller and the switchable filter causes less costs during manufacturing. Further, respective filters are more lightweight.

Such a switchable filter enables to create 3 functions switchable filters: The first partial filter can be dedicated to a first filter function. The first filter structures of the second partial filter can be dedicated to a second filter function and the second filter structures of the second filter can be dedicated to a third filter function.

The first filter function may be realized by the first partial filter being a standalone structure which can be activated or deactivated. The second and the third filter function can be realized by the first and second filter structures which are switchable structures. The first filter structures provide their own signal output and the second filter structures provide their own signal output.

Thus, a switchable filter which can provide three filter functions and one switch circuit is explained. Compared to conventional switchable filters, the demand for area on a SAW chip is reduced and further switch circuits are not necessary.

In one embodiment, in the first state, the first filter structures are electrically connected to the first port. The second filter structures are electrically separated from the first port. Thus, in the first state, the first partial filter and the first filter structures of the second partial filter are active while the second filter structures can be deactivated. As a result, the contribution of the second filter structures to the noise level is reduced.

In one embodiment, the second partial filter comprises first filter structures and second filter structures. In the second state, the first filter structures are electrically separated

from the first port and the second filter structures are electrically connected to the first port. In this configuration of the second state, only the second filter structures of the second partial filters are electrically connected to the first port and to the second port. It is possible that only the second filter structures are active. The first partial filter and the first filter structures of the second partial filters may be inactive. The noise level of signals passing the second filter structures is reduced because the first partial filter and the first filter structures of the second partial filters are decoupled.

In one embodiment, the second partial filter comprises first filter structures and second filter structures. The first partial filter is dedicated to analog audio signals for a first filter functionality. The first filter structures of the second partial filter are dedicated to analog video signals for a second filter functionality and the second filter structures are dedicated to digital signals as a third filter functionality.

In one embodiment the first partial filter is dedicated to analogue audio signals, the first filter structures are dedicated to analog video signals and the second filter structures are dedicated to analogue intercarrier signals.

The intercarrier signal can carry picture, colour and audio information.

Switching off the first partial filter minimizes the interference or cross talk from the first partial filter into the second partial filter. It is especially possible to receive video and audio signals via the second filter

structures only. Then a deterioration caused by the first partial filter and the first filter structures of the second partial filter is reduced.

The first partial filter may be dedicated to audio signals of a passband, e. g. for a sound carrier, from 31.40 MHz to 33.20 MHz and of a second passband from 39.90 MHz to 40.40 MHz.

The first filter structures of the second partial filter may be dedicated to a passband having a bandwidth of 6 MHz and having a center frequency of 36.05 MHz.

The second partial filter may be dedicated to a passband having a bandwidth of 8 MHz and having a center frequency of 36.05 MHz.

The second filter structures of the second partial filter may be dedicated to transmit DVB-T or DVB-C signals in the second state.

In one embodiment, the first partial filter and the second partial filter may be SAW filters that are arranged on a single filter chip, e.g. on the same piezoelectric substrate. The first partial filter can have a first acoustic track and the second partial filter can have a second acoustic track where the first filter structures and the second filter structures of the second partial filters are arranged within the second acoustic track.

In one embodiment, the second partial filter comprises first filter structures and second filter structures. The second partial filter comprises first filter structures and second

filter structures. The first partial filter has a first passband within the interval from 31.40 MHz to 33.20 MHz. The first partial filter has a second passband within the interval from 39.90 MHz to 40.40 MHz. The first filter structures have a passband with a center frequency of 36.05 MHz and a bandwidth of 6 MHz. The second filter structures have a passband with a center frequency of 36.05 MHz and a bandwidth of 8 MHz. These frequencies refer to a temperature of 25° C.

In one embodiment, the switch circuit comprises two diodes and a transistor. The transistor is electrically connected to the control port. A voltage that is applied to the control port drives the transistor to supply the diodes to have a bias voltage that is selected from a forward bias voltage and a reversed bias voltage. Such control voltage pairs can be: 0V / 12 V or 0 V / 5 V.

By supplying the diodes with a forward bias voltage or a respective reversed bias voltage, the diodes act as switches that couple or decouple the first partial filter or filter structures of the second partial filter from the first port. Thus, electrical connections can be electrically separated or deactivated without being separated physically. In other words: biasing the diodes activates or deactivates the respective electrical connection.

The switch circuit may comprise further impedance elements such as capacitive elements or inductive elements.

A respective switch circuit comprising a transistor as the only active switching component can be produced in a cost-efficient manner and provides a good isolation between signal

paths being coupled to the first port, i.e. active signal paths, and signal paths that are decoupled from the first port, i.e. inactive signal paths.

In one embodiment, the switchable filter is electrically connected within the signal path of a broadcast receiving device. The receiving device can be a mobile receiving device such as a portable TV device or a mobile phone. The receiving device can further be a stationary receiving device such as a stationary TV device or DVD recorder. Within a respective broadcast receiving device, the switchable filter can be utilized to switch between different broadcast transmission standards.

In one embodiment, the first port is electrically connected to a reception tuner, e.g. of a TV tuner circuit. The second port is electrically connected to an IC chip, to a decoder or to a demodulator. The reception tuner can be electrically connected to an antenna of a mobile or of a stationary broadcast receiving device. The IC chip can comprise integrated circuits for processing analog or digital video or audio signals in such a way that video signals can be displayed on a screen or audio signals can be converted into acoustic waves by speakers.

In each embodiment the respective signal lines can be balanced or unbalanced signal lines.

Brief description of the drawings

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

FIG. 1 shows a schematic circuit equivalent diagram,

FIG. 2A shows the switching circuit having a first state,

FIG. 2B shows the switching circuit having a second state,

FIG. 3 shows the second partial filter having first and second filter structures,

FIG. 4 shows an SAW filter having a first and a second filter structure within the same acoustic track,

FIG. 5 shows a broadcasting reception device,

FIG. 6 shows a switchable filter circuit being electrically connected to a reception tuner and to an IC circuit,

FIG. 7 shows an embodiment of the switch circuit.

FIG. 1 shows schematically a switchable filter SF. A first partial filter PF1 is electrically connected between a switch circuit SWC and a second port P2. A second partial filter PF2 is electrically connected between the switch circuit SWC and the second port P2. The second partial filter PF2 and the first partial filter PF1 are, thus, electrically connected in parallel. The switch circuit SWC is electrically connected between a first port P1 and the respective partial filters PF1, PF2. The switch circuit SWC has a control port CP for controlling the switching state of the switching circuit SWC.

FIG. 2A shows schematically the switch circuit SWC being in a first switching state ST1.

FIG. 2B shows, in contrast to FIG. 2A, the switching state SWC being in a second switching state ST2.

In the first switching state ST1, the first partial filter PF1 of FIG. 1 is electrically connected to the first port. In the second switching state ST2, the first partial filter PF1 of FIG. 1 is electrically separated from the first port P1.

By separating the first partial filter PF1 from the first port in the second state ST2, the noise level in the second partial filter and cross-talk between both partial filters is reduced.

FIG. 3 shows an embodiment of the switchable filter SF where the second partial filter PF2 comprises first filter structures FS1 and second filter structures FS2. In the first state ST1 of the switch circuit SWC, the first partial filter PF1 and the first filter structure FS1 of the second partial filter PF2 are electrically connected in parallel between the switch circuit and the second port P2. The second filter structures FS2 of the second partial filter PF2 are electrically separated from the first port P1.

The configuration shown in FIG. 3 allows to have two different switch states where in the first switch state ST1, the first partial filter and the first filter structures FS1 of the second partial filter PF2 are commonly used. In the second switch state ST2, the first partial filter and the first filter structures FS1 of the second partial filter PF2 are decoupled from the first port and only the second filter structures FS2 of second partial filter PF2 are connected to the first port via the switch.

FIG. 4 shows schematically an SAW filter SAWF having a filter chip FC. The filter chip FC comprises a piezoelectric substrate PSU. Two acoustic tracks AT1, AT2 are arranged on the piezoelectric substrate PSU. The phrase "acoustic track" generally denotes the area on a piezoelectric substrate in which surface acoustic waves propagate. The SAW filter SAWF comprises interdigitated transducers that are arranged within the acoustic tracks between acoustic reflectors.

The upper acoustic track AT1 comprises one set of transducers while the lower acoustic track AT2 comprises two sets of transducers within the same acoustic track. Such SAW filters, e.g. for dual filter purposes, are known from the above US patent US 5,867,075.

FIG. 5 illustrates a broadcasting receiving device BRD in which a respective switchable filter can be utilized. The switchable filter may be electrically connected via a reception tuner to an antenna.

FIG. 6 shows a switchable filter SF that is electrically connected between a reception tuner RT and an IC chip ICC. The switch circuit SWC can be controlled by applying a control voltage via the control port CP.

In FIG. 6 both signal lines of the second port are connected to the same IC Chip ICC. However, it is possible that each signal line of the second port P2 can be connected to a different IC Chip.

FIG. 7 shows an embodiment of the switch circuit SWC. Digital or analog signals that may be video or audio signals may be feed in by the switch circuit SWC via the first port P1. Via

a switch filter connection SFC, the switch circuit SWC is electrically connected to the first partial filter and to the second partial filter. A control voltage may be applied to the control port CP. A supply voltage may be applied to the voltage supply port VSP. Capacitive elements C1, C2, and C3 electrically connect the voltage supply port VSP to ground. A resistive element R6 is electrically connected between the switch circuit transistor TR and the control port CP. A resistive element R7 is electrically connected between the transistor TR and ground. The voltage supply port VSP is electrically connected to the transistor TR via a resistive element R2. A first diode D1 is electrically connected to the voltage supply port via a resistive element R3. The second diode D2 is electrically connected to the voltage supply port via a resistive element R1. The first diode D1 is electrically connected to ground via a resistive element R4 and the diode D2 is electrically connected to ground via a resistive element R5.

The switch filter connection SFC comprises three elemental ports. One port is electrically connected to the transistor TR via a first inductive element L1. A second port is electrically connected to the first port P1 via a capacitive element C4. A third port is electrically connected to the first port P1 via a capacitive element C5. The latter two ports of the switch filter connection are electrically connected by a second inductive element L2.

The first port P1 comprises two elemental ports which may receive a balanced data signal being provided by a BALUN (BALanced/UNbalanced converter).

The control voltage being applied to the control port CP may be either 0 V for the first state or 12 V for the second state. By applying the control voltage to the control port, the transistor TR provides the diodes D1, D2 with respective bias voltages. As a result, the diodes D1, D2 act as switches that electrically connect the first partial filter to the first port in the first state and that electrically separate the first partial filter from the first port in the second state.

In FIG. 7 the capacitive elements C4 and C5 are electrically connected within the two signal lines of a balanced signal line.

The first port P1 can be dedicated to transmit balanced or unbalanced signals. The second port P2 can be dedicated to transmit balanced or unbalanced signals.

The basic concept does not depend on technologic details of switching elements or the partial filters. Variations of the switch circuit that comprise different means for switching or that comprise further active or passive switching elements or first and second partial filters being other filters than SAW filters or comprising other electrode structures are also possible. The invention is not restricted by the embodiments described above or by the accompanying figures.

List of reference signs:

AT1, AT2: acoustic track
BRD: broadcast receiving device
CP: control port
D1, D2: first, second diode
FC: filter chip
FS1, FS2: first, second filter structures
ICC: IC chip
P1, P2: first, second port
PF1, PF2: first, second partial filter
PSU: piezoelectric substrate
RT: reception tuner
SFC: switch filter connection
SF: switchable filter
ST1, ST2: first, second state
SAWF: SAW filter
SWC: switch circuit
TR: transistor
VSP: voltage supply port

Claims:

1. Switchable filter (SF), comprising
- a first partial filter (PF1) and a second partial filter (PF2),
- a first port (P1) and a second port (P2), and
- a switch circuit (SWC) having a control port (CP),
where
- the switch circuit (SC) can switch between a first state (ST1) and a second state (ST2),
- the first partial filter (PF1) is electrically connected between the switch circuit (SC) and the second port (P2),
- the second partial filter (PF2) is electrically connected between the switch circuit (SC) and the second port (P2), the second partial filter (PF2) being electrically connected parallel to the first partial filter (PF1),
- the switch circuit (SC) is electrically connected to the first port (P1), to the first partial filter (PF1), and to the second partial filter (PF2),
- a control signal applied to the control port (CP) determines the state (ST1, ST2) of the switch circuit (SC),
- in the first state (ST1) the first partial filter (PF1) is electrically connected to the first port (P1),
- in the second state (ST2) the first partial filter (PF1) is electrically separated from the first port (P1).

2. Filter of the previous claim, where
the first partial filter (PF1) and the second partial filter (PF2) are SAW filters (SAWF).

3. Filter of the previous claim, where the second partial filter (PF2) comprises first filter structures (FS1) and second filter structures (FS2), both filter structures (FS1, FS2) being arranged within the same acoustic track (AT2).

4. Filter of one of the previous claims, where in the first state (ST1)
- the first filter structures (FS1) are electrically connected to the first port (P1) and
- the second filter structures (FS2) are electrically separated from the first port (P1).

5. Filter of one of the previous claims, where
- the second partial filter (PF2) comprises first filter structures (FS1) and second filter structures (FS2),
- in the second state (ST2), the first filter structures (FS1) are electrically separated from the first port (P1) and the second filter structures (FS2) are electrically connected to the first port (P1).

6. Filter of one of the previous claims, where
- the second partial filter (PF2) comprises first filter structures (FS1) and second filter structures (FS2),
- the first partial filter (PF1) is dedicated to analogue signals and
- the first filter structures (FS1) are dedicated to analogue signals and the second filter structures (FS2) are dedicated to digital signals.

7. Filter of one of the previous claims, where
- the first partial filter (PF1) is dedicated to analogue audio signals,

- the second partial filter (PF2) comprises first filter structures (FS1) and second filter structures (FS2),
- the first filter structures (FS1) are dedicated to analog video signals,
- the second filter structures (FS2) are dedicated to analogue intercarrier signals.

8. Filter of one of the previous claims, where the first partial filter (PF1) and the second partial filter (PF2) are arranged on a single filter chip (FC).

9. Filter of one of the previous claims, where
- the second partial filter (PF2) comprises first filter structures (FS1) and second filter structures (FS2),
- the first partial filter (PF1) has a first passband within the interval from 31.40 MHz to 33.20 MHz,
- the first partial filter (PF1) has a second passband within the interval from 39.90 MHz to 40.40 MHz,
- the first filter structures (FS1) have a passband with a center frequency of 36.05 MHz and a bandwidth of 6 MHz,
- the second filter structures (FS2) have a passband with a center frequency of 36.05 MHz and a bandwidth of 8 MHz.

10. Filter of one of the previous claims, where
- the switch circuit (SC) comprises two diodes (D1, D2) and a transistor (TR),
- the transistor (TR) is electrically connected to the control port (CP),
- a voltage that is applied to the control port (CP) drives the transistor (TR) to supply the diodes (D1, D2) to have a bias voltage that is selected from: a forward bias voltage and a reversed bias voltage.

11. Filter of one of the previous claims, being electrically connected within the signal path of a broadcast receiving device (BRD).

12. Filter of one of the previous claims, where
- the first port (P1) is electrically connected to a reception tuner (RT) and
- the second port (P2) is electrically connected to a IC chip (ICC), a decoder or a demodulator.

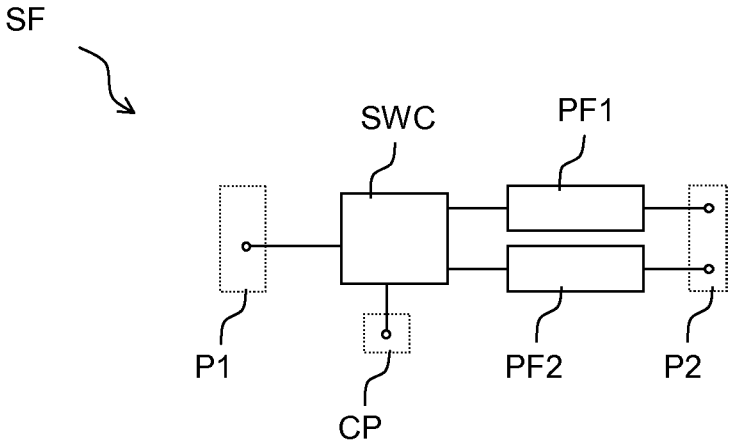

Fig. 1

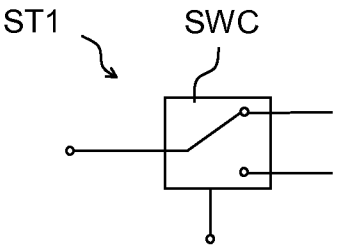

Fig. 2a

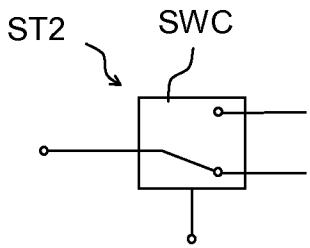

Fig. 2b

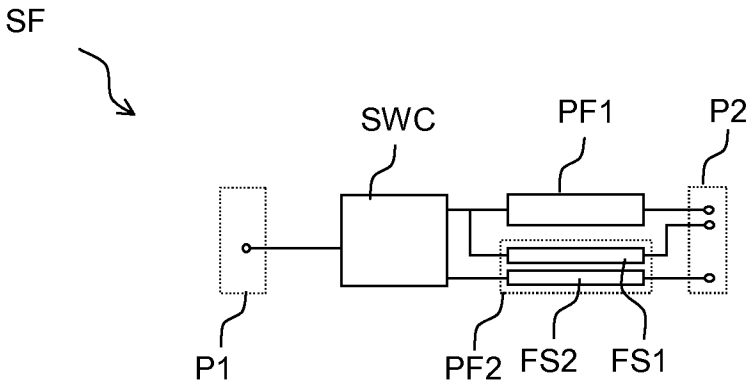

Fig. 3

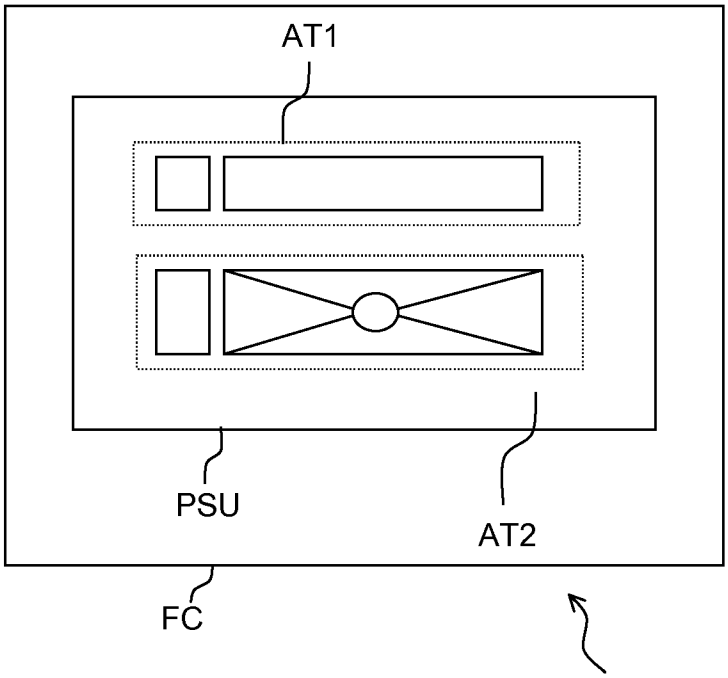

Fig. 4

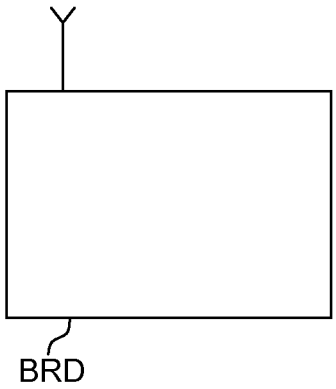

Fig. 5

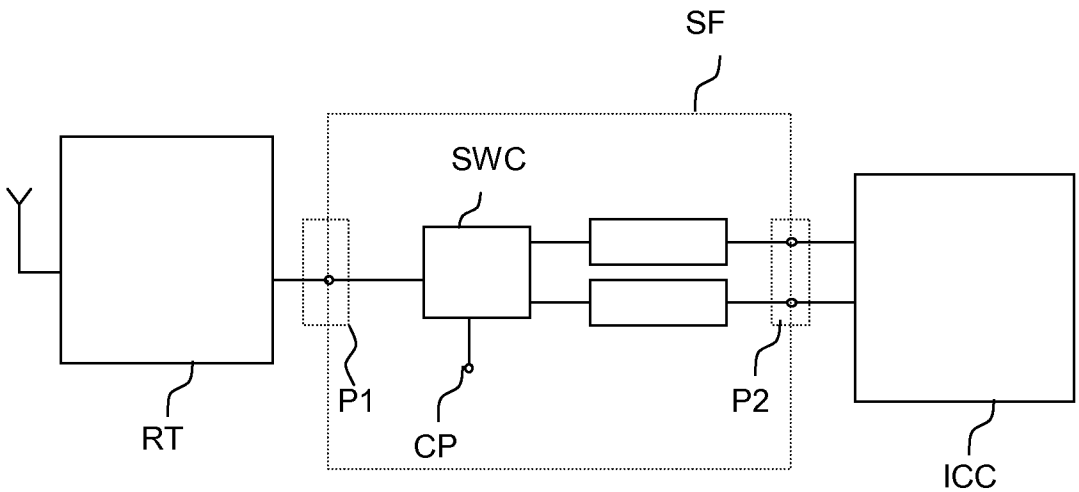

Fig. 6

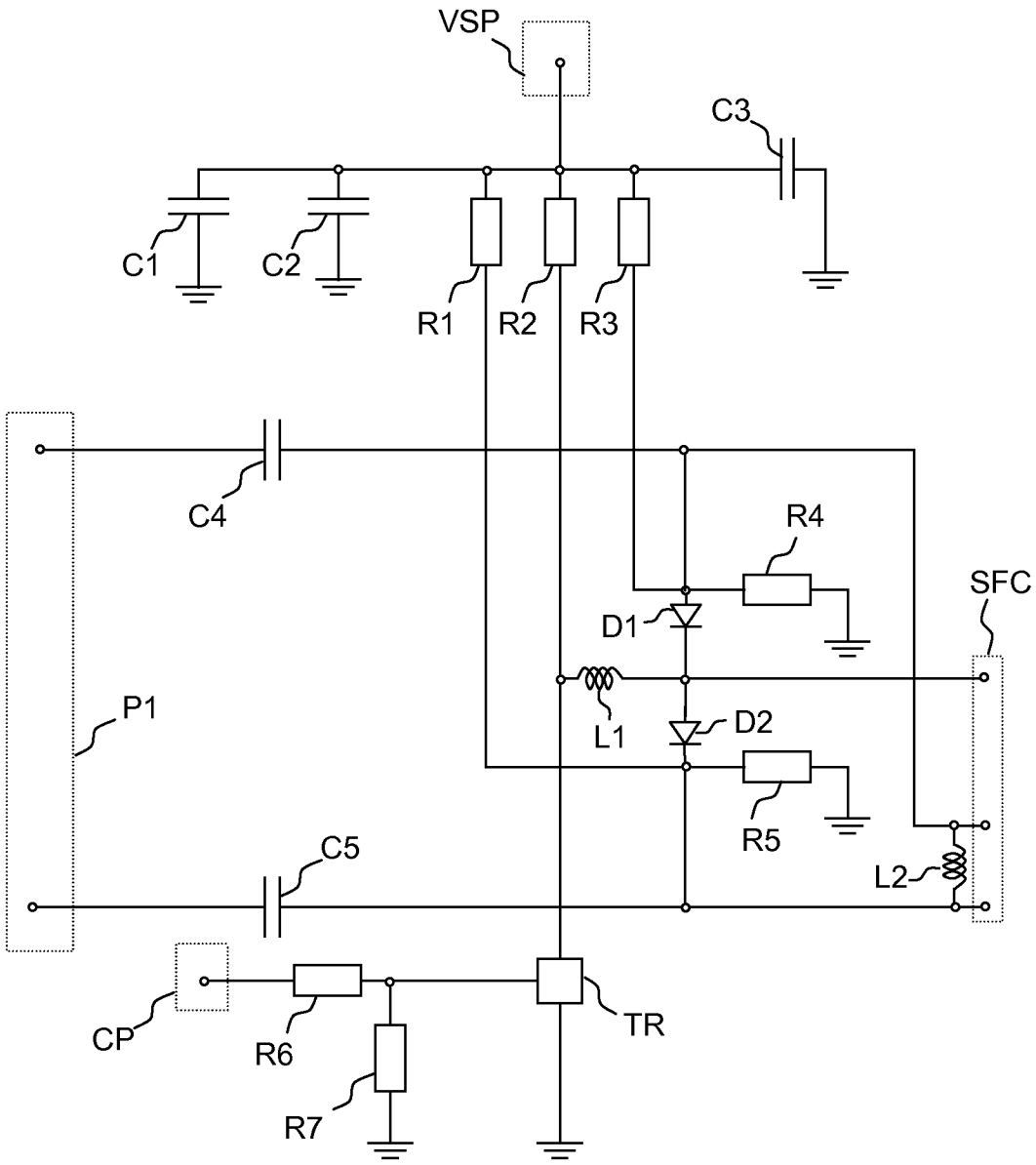

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/066383

A. CLASSIFICATION OF SUBJECT MATTER
INV. H03H9/72 H04N5/46 H04B1/18 H04B1/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H03H H04B H04N H03K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EPCOS AG: "SAW Components" In: "SAW IF Filter X 3751 L - Switchable Bandpass filter and double hump audio filter formultistandard TV applications", 18 December 2008 (2008-12-18), EPCOS AG, XP55002504, pages 1-13,	1,2,4-9, 11,12
Y	pages 2-5	3,10
X	US 5 673 088 A (NAH IL-KOO [KR]) 30 September 1997 (1997-09-30) abstract; figures 4,8 column 6, lines 35-67	1-3,8, 10-12
X	US 2008/218927 A1 (HARADA TETSURO [JP] ET AL) 11 September 2008 (2008-09-11) paragraphs [0040] - [0054]; figure 1	1,2,4,5

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

International application No
PCT/EP2010/066383

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