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Multi-tuner receiver.

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FIELD OF THE INVENTION

The invention relates to a receiver comprising at least two tuners for concurrent reception of mutually different signals. The invention also relates to a multimedia apparatus and an add-on card comprising such a receiver.

5 BACKGROUND ART

The Philips television (TV) set type 32PW9761 comprises two tuner modules for allowing a concurrent display of two mutually different TV programs. TV programs are broadcast at various respective radio frequencies in a range from, say, 45 MHz to 860 MHz. The broadcasted TV programs enter the TV set via a radio frequency inlet and are supplied to the two tuner modules via a splitter in the TV set. Each of the two tuner modules has a shielded encasing which houses an oscillator and a mixer for converting a radio frequency to an intermediate frequency of, say, 40 MHz. The respective oscillators have adjustable oscillation frequencies. An oscillation frequency determines which radio frequency, and therefore which broadcasted TV program, is converted to the 40 Mhz intermediate frequency for further processing so as to be displayed. If, for example, the oscillation frequency is 500 MHz, a TV program which is broadcast at a 460 MHz radio frequency, is converted to the 40 MHz intermediate frequency and, consequently, may be displayed.

20 SUMMARY OF THE INVENTION

The invention seeks, inter alia, to provide a receiver of the subject type which, with respect to the background art, allows more cost-efficient implementations. Claims 1 and 8 define receivers in accordance to the invention. Claims 9, 10, 11 and 12 respectively define a method of receiving, a multimedia apparatus, an add-on card and a single shielded encasing, all in accordance with the invention. Additional features, which may optionally be used to implement the invention to advantage, are defined in the dependent Claims.

The invention takes the following aspects into consideration. Up to the

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present, the demand for receivers which can concurrently receive mutually different signals, has been relatively low. To give an example, of the total number of TV sets sold, only a relatively small percentage has two tuners to allow, for example, a picture-in-picture (PIP) functionality. For that reason, it currently is cost-efficient to implement PIP TV sets in a background-art manner. That is, two separate tuner modules are used which are individually also applicable in many other types of TV sets and, therefore, are produced in relatively large quantities and, therefore, are relatively cheap.

However, the situation may be different in the future. The amount of information and entertainment offered to consumers is increasing rapidly. With that, the variety of ways in which information and entertainment is offered, is also increasing. For example, it may be transmitted in an analog or digital form via satellite, cable TV networks, telephone networks, et cetera. Furthermore, multimedia tends to centralize various types of information like text, data, audio and visual information. In view of the aforementioned, the demand for receivers which can concurrently receive mutually different signals, may increase to such a level, that other solutions than the background-art solution may be more cost-efficient.

In accordance with the invention, two or more tuners are merged into one module. If the two or more tuners are merged, various components may be shared by the two or more tuners like, for example, crystals, integrated circuits, printed wire boards, metal ware, connectors, and pin blocks. Costs which will be saved if various components are shared, may outweigh costs related to merging the two or more tuners into one module, once the demand for receivers of the subject type is sufficiently high.

The invention and additional features, which may optionally be used to implement the invention to advantage, will be apparent from and elucidated with reference to the drawings described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a conceptual diagram illustrating the basic principles of the invention;

Fig. 2 to 7 are diagrams illustrating additional features which may optionally be used to implement the invention to advantage;

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Fig. 8 is a block schematic diagram of an example of a receiver in accordance to the invention; and

Fig. 9 is a diagram illustrating an example of a multimedia apparatus in accordance with the invention.

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DETAILED DESCRIPTION OF THE DRAWINGS

First, some remarks are made on the use of reference signs. Similar
10 entities will be denoted with an identical lettercode throughout the drawings. In a single drawing, various similar entities may be shown. In that case, a numeral will be added to the lettercode, to distinguish similar entities from each other. Furthermore, if an entity forms part of a higher entity, the numeral in the reference sign of the entity will indicate that it belongs to the higher entity which has the same numeral in its reference
15 sign. In the description, and in the claims, any numeral in a reference sign may be omitted if this is appropriate.

Fig. 1 illustrates the basic principle of the invention. In Fig. 1, at least two tuners TUN1, TUN2 are merged into one module MOD. Although Fig. 1 shows two tuners TUN1, TUN2, further tuners may be merged into the same module MOD.

20 Fig. 2 illustrates that each of the two tuner TUN1, TUN2 has an oscillator OSC coupled to a mixer MIX for converting a signal at a radio frequency to an intermediate frequency. Fig. 2 also illustrates the following additional feature. The oscillator of each of the two tuners has an oscillation frequency, Fosc1 or Fosc2, which does not coincide with the radio frequency, RF2 or RF1 respectively, or any
25 sub-harmonic of the radio frequency, of the signal received by the respective other tuner. This preferably applies substantially throughout respective tuning ranges of the two tuners TUN1, TUN2.

The Fig. 2 feature is based on the following considerations. The two tuners TUN1, TUN2 which are merged into one module may mutually interfere each
30 other. In particular, the oscillator of one of the two tuners, may interfere with the signal received by the respective other tuner. An oscillator signal may propagate to various points in the receiver in many different ways. For example, it may propagate by means of induction in metal parts and by means of crosstalk into printed wire board tracks



which carry, for example, switching signals and varicap voltages. The overall propagation attenuation which the oscillator signal experiences, is often highly unpredictable and, moreover, it may vary strongly as a function of frequency. This is an important fact, since the oscillator signal may not only comprise a fundamental
5 frequency component but also harmonic frequency components as well. The amplitude of an harmonic frequency component may therefore be higher than that of the fundamental frequency component at certain points in the receiver.

There are various ways to counter the above described mutual interference. One solution could be to keep oscillator signals at sufficiently low levels.
10 However, if an oscillator signal level is reduced, this will generally degrade performance in terms of noise and frequency stability.

An other solution could be to electro-magnetically shield the oscillators. However, shielding is relatively expensive and, in some cases, it may even be insufficiently effective. The following example is given as an illustration. In TV
15 reception, an interference distance of at least 60 dB is desirable. Assuming that the level of a TV signal received by a tuner is 1 mV, which is a typical, the level of an interfering signal may not exceed 1 μ V. Assuming that the level of the oscillator signal in an other tuner is 1 V, which is typical, a 120 dB attenuation is needed between the two tuners. If the two tuners are merged into one module, any internal shielding for
20 providing such attenuation, if feasible at all, will be costly and, moreover, difficult to design.

Yet another solution could be to block reception for radio-frequency combinations at which the two tuners TUN1, TUN2 would mutually interfere. This may be achieved by means of, for example, a suitably programmed computer which controls
25 the two tuners TUN1, TUN2. However, as also harmonic frequency components of oscillator signals need to be taken into account, it may be needed to block reception for relative many radio-frequency combinations. In that case, end users will be stuck with a relatively constrained variety of signals which can be concurrently received.

If the Fig. 2 feature is applied, neither the fundamental frequency
30 component nor any harmonic frequency component of an oscillator signal in any of the two tuners TUN1 or TUN2, will directly interfere with the signal being received by the respective other tuner, TUN2 or TUN1, respectively. The oscillators OSC1, OSC2 are therefore allowed to operate at signal levels which provide satisfactory performance in



terms of noise and stability. What is more, this does neither require relatively elaborate shielding nor blocking reception for relatively many radio-frequency combinations. Thus, the Fig. 2 feature contributes to quality and versatility of reception and cost-efficiency, either in combination or as such.

5 The Fig. 2 feature will provide an additional advantage, if a splitter is used to apply signals to the two tuners TUN1, TUN2 from a common terminal. In that case, the splitter need not provide high attenuation between the two tuners TUN1, TUN2 in order to prevent mutual interference. For that reason, the splitter may be realized with relatively few active components, or it may even be realized without any active
10 components. Active components consume power and produce noise and distortion. Thus, the Fig. 2 feature allows a relatively power-efficient, noiseless and distortionless splitter. It should be noted that these advantages will also be obtained, if two tuners are separate, as in the background art.

 Fig. 3a illustrates the following additional feature. The oscillation
15 frequency Fosc1 in tuner TUN1 exceeds the highest possible radio frequency RFmax2 which tuner TUN2 can receive. This preferably applies substantially throughout the tuning range of the tuner TUN1.

 The Fig. 3a feature is based on the following considerations. If the tuner TUN1 needs to be tunable throughout a relatively wide tuning range, it may be difficult
20 to avoid coincidence of the oscillation frequency Fosc1 with the radio frequency RF2, or any sub-harmonic of the radio frequency RF2, of the signal received by tuner TUN2. Relatively complicated and, hence, costly measures may be needed to avoid such coincidence. However, if the Fig. 3a feature is applied, any such coincidence will be excluded by definition. Thus, the Fig. 3a feature contributes to cost-efficiency, in
25 particular if the tuner TUN1 needs to be tuned throughout a relatively wide tuning range.

 Fig. 3b illustrates the following additional feature. The oscillation frequency, Fosc1 or Fosc2, in each of the two tuners exceeds the highest possible radio frequency, RFmax2 or RFmax1, respectively, which the respective other tuner can
30 receive. The Fig. 3b feature is effectively an addition to the Fig. 3a feature. The addition is that the oscillation frequency Fosc2 in tuner TUN2 also exceeds the highest possible radio frequency RFmax1 which tuner TUN1 can receive. Thus, the Fig. 3b feature contributes to cost-efficiency, in particular if the two tuners TUN1, TUN2 both



need to be tuned throughout a relatively wide tuning range.

The following remarks are made with respect to the Figs. 3a and 3b features. When the Fig. 3a feature is applied, provisions may be made that the tuner TUN1 receives the signal with the lower radio frequency and that, consequently, the
5 tuner TUN2 receives the signal with the higher radio frequency. If, in addition, the oscillation frequency F_{osc2} in the tuner TUN2 is located above the radio frequency RF2 of the signal received by this tuner, it will for sure exceed the radio frequency RF1 of the signal received by the tuner TUN1. The overall result will be that the oscillation frequency F_{osc1} or F_{osc2} in each of the two tuners will exceed the radio frequency
10 RF2 or RF1, respectively, received by the other tuner. Consequently, neither fundamental components nor any harmonic components of the oscillation signals can interfere with the signals received. Thus, the Fig. 3a feature can provide advantages similar to those of the Fig. 3b feature.

Notwithstanding that what is mentioned above, the Fig. 3b feature may be
15 preferable over the Fig. 3a feature for the following reason. Assume that two signals $S(X)$ and $S(Y)$ are concurrently received. The signal $S(Y)$ has a higher radio frequency than signal $S(X)$. The reception signal $S(Y)$ needs to be discontinued in favour of an other signal $S(Z)$ which has a lower radio frequency than $S(X)$. The following will happen in the case of Fig. 3a with the provisions as described above. The tuner TUN2
20 will have to take over the reception of signal $S(X)$, which is maintained, from the tuner TUN1. Such a take-over is needed in view of the higher-lower radio frequency relation. The take-over may cause an interruption in reception of signal $S(X)$. In contradistinction, any take-over will not be needed if the Fig. 3b feature is applied. Thus, the Fig. 3b feature allows an uninterrupted reception while changing any
25 concurrent reception.

Fig. 4 illustrates the following additional feature. The difference ΔF_{osc} between the oscillation frequencies F_{osc1}, F_{osc2} in the two tuners TUN1, TUN2, exceeds an intermediate frequency bandwidth BWIF. This preferably applies substantially throughout the respective tuning ranges of the two tuners TUN1, TUN2.

30 The Fig. 4 feature is based on the following considerations. The oscillators OSC1, OSC2 may mutually phase modulate each other as a result of mutual electro-magnetic coupling. This will cause the oscillator signals to have sidebands. Fig. 4 shows sidebands F_{sb+1}, F_{sb-1} belonging to oscillator OSC1 and sidebands



Fsb+2,Fsb-2 belonging to oscillator OSC2. The sidebands are located at $+\Delta F_{osc}$ and $-\Delta F_{osc}$ from the oscillation frequencies Fosc1,Fosc2. The sidebands of each oscillator signal will mix with the respective signal received. As a result, the signals received which have been converted to the respective intermediate frequencies, will also have
5 sidebands located at $+\Delta F_{osc}$ and $-\Delta F_{osc}$ from these respective intermediate frequencies.

If the Fig. 4 feature is applied, the aforementioned sidebands will not directly interfere with the respective signal received. Thus, the Fig. 4 feature counters mutual interference between the two tuners TUN1,TUN2 which may arise as a result of
10 mutual electromagnetic coupling of their oscillators. Consequently, there will be relatively little need to counter such mutual electro-magnetic coupling with measures as, for example, providing internal shielding or improving the quality Q of an oscillator tank circuit. Such measures are relatively costly, in particular at relatively high frequencies. Hence, the Fig. 4 feature contributes to cost-efficiency.

15 The following additional remarks are made with respect to the Fig. 4 feature. The sidebands Fsb+ ,Fsb- could cause intermodulation products which may harm reception. However, the respective sidebands will generally have such a small amplitude that, in many cases, this form of mutual interference may be neglected. Furthermore, the amplitude of the respective sidebands Fsb+ ,Fsb- will decrease, if the
20 difference ΔF_{osc} between the oscillator frequencies Fosc1,Fosc2 increases.

When one of the two tuners TUN1,TUN2 is operated in an auto search mode, it may be advantageous to skip a frequency range where mutual phase modulation can occur e.g. by measures in software. To that respect it should also be noted that any harmonics of the oscillation frequencies Fosc1,Fosc2, do not substantially
25 contribute to any mutual phase modulation of the oscillators OSC1,OSC2. Thus, there will be little or no mutual phase modulation if one of the oscillator frequencies, Fosc1 or Fosc2, is relatively close to an harmonic of the other oscillator frequency, Fosc2 or Fosc1, respectively. Consequently, if the frequency ranges of the oscillators OSC1,OSC2 do not overlap, any skip during an auto search will not be necessary.

30 Fig. 5a illustrates the following additional feature. A frequency divider DIV1 is coupled between the oscillator OSC1 and the mixer MIX1 in the tuner TUN1. Before any advantages of this feature are discussed, the following should be noted. The frequency divider DIV1 generates a sub-harmonic of the oscillator signal. In principle,



the sub-harmonic may interfere with the signal received by the tuner TUN2, not shown in Fig. 5a. Thus, the divider DIV1 as well as circuitry coupling it to mixer MIX1, should be regarded as a potentially interfering transmitters. However, with proper design, these potentially interfering transmitters will be appreciably weaker than the
5 potentially interfering transmitter which the oscillator OSC1 would have been if the invention were not used. Consequently, the Fig. 5a feature does not withstand a merging of two tuners in a manner which would not have been possible in the background art.

An advantage of the Fig. 5a feature will be explained with reference to
10 Fig. 5b. Fig. 5b is a frequency diagram showing the radio frequency RF1, the oscillation frequency Fosc1, and a mixing frequency Fmix1. The mixing frequency Fmix is the oscillation frequency Fosc1 divided by N1, N1 being the division factor of the frequency divider DIV1. Fig. 5b also shows the intermediate frequency IF1 which is the difference between the mixing frequency Fmix1 and the radio frequency RF1.

15 Assuming that the intermediate frequency IF1 preferably has a certain desired value, for example 40 MHz in the case of TV reception, an advantage of the Fig. 5a feature is as follow. It allows the oscillation frequency Fosc1 to be such that mutual interference between the two tuners TUN1, TUN2, as described in the foregoing, can be countered by a suitable choice of the division factor N1 of the frequency divider
20 DIV1. If, in addition, a frequency divider is also coupled between the oscillator OSC2 and the mixer MIX2 in the tuner TUN2, all shown in Fig. 1, this will provide a greater number of possibilities to counter mutual interference. The division factor of the last mentioned divider introduces, as it were, an extra measure of freedom to achieve this.

The following additional remarks are made with respect to the Fig. 5a
25 feature. The Fig. 5a feature is neither essential to the invention, nor is it essential to any of the other features described above. The oscillation frequency Fosc1, shown in Fig. 5b, may be directly applied to the mixer MIX1 without any frequency division. However, in that case the intermediate frequency would be the difference between the oscillation frequency Fosc1 and the radio frequency RF1. Consequently, the
30 intermediate frequency would be higher. Circuitry for processing relatively high intermediate frequency signals is relatively costly, power-consuming and/or critical. Consequently, because the Fig. 5a feature allows a relatively low intermediate frequency, it contributes cost-efficiency, power-efficiency and robustness.



Fig. 6 illustrates the following additional feature. The division factor $N1$ of the frequency divider DIV1, shown in Fig. 5a, is adjustable. Fig. 6 shows various mixing frequency ranges $R2, R3, R4, R6, R8, R12, R16$ obtained with division factors $N1=2, 3, 4, 6, 8, 12, 16$, respectively, if the oscillator OSC1 is tunable between 1000 and 2000 MHz. Thus, if the frequency divider DIV1 can be adjusted to have any of these division factors, it allows mixing frequencies throughout a range extending from 62.5 MHz to 1000 MHz. If, however, the division factor $N1$ were fixed, the oscillator OSC1 would have to be tunable over a wider range, to allow a similar choice of mixing frequencies. This would make it more difficult, or even impossible, to realize the oscillator OSC1. As a solution, several tunable oscillators could be used, each tunable oscillator covering a certain portion of the range of mixing frequencies. This solution is common in TV where, for example, oscillators are used for the bands VHF-low, VHF-high and UHF, respectively. The Fig. 6 feature, however, allows tuning throughout a relatively wide frequency range with a single oscillator which needs only to be tuned over a relatively narrow frequency range. Consequently, the Fig. 6 feature contributes to cost-efficiency.

Fig. 6 also illustrates the following advantageous additional feature. Over a substantial portion of the range of mixing frequencies, namely between 83.33 MHz and 666.67 Mhz, there is more than one oscillator frequency with which a certain mixing frequency can be obtained. In other words, for a certain mixing frequency, there is a choice of oscillator frequencies. This choice allows the oscillator frequency F_{osc1} in the tuner TUN1 to be relatively distant from the oscillator frequency F_{osc2} in the tuner TUN2, thereby countering mutual interference. To that effect, it does not matter if the oscillators OSC1, OSC2 operate in respective frequency ranges which overlap. A suitably chosen division factor $N1$ can prevent the oscillators OSC1, OSC2 from being too close in frequency. Moreover, if an adjustable frequency divider is also coupled between the oscillator OSC2 and the mixer MIX2 in tuner TUN2, there will be an even greater choice in keeping the oscillation frequencies F_{osc1}, F_{osc2} apart. Suitable software may be used to choose the optimal division factor, or division factors, in a certain case.

In Fig. 6, two frequency ranges remain for which no choice in oscillation frequency exist, namely a frequency range below 83.33 MHz and a frequency range above 666.67 Mhz. Although it would be advantageous if there were a choice within



these frequency ranges, any absence of choice will in most cases not lead to a noticeable mutual interference. First of all, two tuners generally need not concurrently receive at the same radio frequency or almost the same radio frequency, in which case the oscillation frequencies F_{osc1}, F_{osc2} would coincide or nearly coincide, respectively.

- 5 Furthermore, it hardly occurs that two adjacent radio-frequency channels are occupied by usable signals and, therefore, the need for simultaneous reception at two adjacent radio-frequency channels is very slim. In the unlikely event that such reception is needed, the oscillation frequencies F_{osc1}, F_{osc2} will be spaced apart by an amount which is N times the distance between the two adjacent radio-frequency channels, N being the identical division factor of the dividers $DIV1, DIV2$. Thus, because the oscillation frequencies F_{osc1}, F_{osc2} are divided, they will be relatively spaced apart such that any sidebands, as a result of mutual phase modulation, will fall outside the intermediate frequency bandwidth, even if an identical division factor is used.

- Fig. 7 illustrates the following additional feature. The mixer $MIX1$ and the frequency divider $DIV1$ form part of an integrated circuit $MOIC1$. Hence, the circuitry carrying the sub-harmonic $F_{osc1} \div N1$ of the oscillation signal, has a small geometry. As a result, any radiation of the sub-harmonic $F_{osc1} \div N1$, which may potentially interfere with the signal received by the tuner $TUN2$, will be relatively modest. Consequently, the Fig. 7 feature enhances the extent to which the two tuners $TUN1, TUN2$ may be merged.

- The following additional remarks are made with respect to the Fig. 7 feature. First of all, the mixer $MIX1$ is preferably implemented in the form of a balanced circuit. This provides inherent suppression of any oscillator sub-harmonic residues at input and output ports of the mixer circuit $MIX1$. Preferably, the divider $DIV1$ is also implemented in the form of a balanced circuit. Secondly, it should be noted that the integrated circuit $MOIC1$ may comprise further circuits. The dotted lines in Fig. 7 illustrate that the oscillator $OSC1$ may wholly or partially be included in the integrated circuit $MOIC1$. If the tuner $TUN2$ also comprises a frequency divider coupled between the mixer $MIX2$ and the oscillator $OSC2$, these circuits may also form part of the integrated circuit $MOIC1$. As an other example, the integrated circuit $MOIC1$ may also include a phase-lock loop circuit.

Fig. 8 shows an example of a receiver in accordance with the invention and including the Figs. 2 to 7 additional features. The Fig. 8 receiver is a dual TV/FM



receiver capable of concurrently receiving two mutually different TV stations, or two mutually different FM-radio stations, or a TV station and an FM-radio station. To that end, it comprises two tuners TUN1, TUN2 for concurrently converting two mutually different radio-frequency signals $Si_1(RF)$ and $Si_2(RF)$ to intermediate frequency signals $So_1(IF)$ and $So_2(IF)$, respectively. Any of the radio-frequency signals $Si_1(RF)$ and $Si_2(RF)$ may either be a TV station or an FM-radio station, received at radio-frequency inlets $I(TV)$ and $I(FM)$, respectively.

In Fig. 8, each of the two tuners TUN1, TUN2 includes a switch SW, three radio-frequency input circuits RFIL, RFIM and RFIH, and an integrated circuit MOIC. Radio-frequency input circuits RFIL, RFIM and RFIH are arranged for processing signals within a VHF-low band, a VHF-high band and a UHF band, respectively. Each of the integrated circuits MOIC houses a mixer MIX, a divider DIV and an amplifier portion AMP of an oscillator OSC. A resonator portion RES of the oscillator OSC is external to the integrated circuit MOIC. Each of the integrated circuits MOIC further houses a phase-lock loop circuit PLL and a digital-to-analog conversion arrangement DAC. The two tuners TUN1, TUN2 share a memory circuit MEM and a crystal XTL which resonates at a reference frequency Fref.

Each of the two tuners TUN1, TUN2 operates as follows. The switch SW is set to a position TV or a position FM depending on whether reception of a TV station or an FM-radio station is desired. In the first case, a radio frequency signal $Si(RF)$ may be processed in any of the three radio-frequency input circuits RFIL, RFIM or RFIH. In the latter case, that of FM-radio reception, the radio-frequency signal $Si(RF)$ is processed by the radio frequency input circuit RFIL for the VHF-low band. In any case, the relevant radio-frequency input circuit supplies a suitably processed radio-frequency signal $Sp(RF)$ to the mixer MIX in the integrated circuit MOIC.

The radio-frequency input circuits RFIL, RFIM and RFIH comprise tunable bandpass filters which are not shown for reasons of conciseness. Tuning voltages VT, which control the tunable bandpass filters, are obtained as follows. Control data CON, which comprises information on the desired radio-frequency, effectively selects which tuning data TD is read from the memory MEM for supply to the digital-to-analog converter arrangement DAC. The selected tuning data TD is such that the digital-to-analog conversion arrangement DAC provides the tuning voltages VT for which the relevant radio-frequency input circuits suitably processes the desired



radio-frequency signal $S_i(\text{RF})$. Accordingly, with appropriate tuning data stored in the memory MEM, the bandpass filters may satisfactorily be tuned throughout the VHF-low, VHF-high and UHF bands. Any aberrations in the tuning of the bandpass filters relative to each other may be reduced by means of a manual adjustment.

5 The mixer MIX in the integrated circuit MOIC effectively multiplies the suitably processed radio-frequency signal $S_p(\text{RF})$ with a mixing signal S_{mix} having a mixing frequency F_{mix} . In principle, the mixing frequency may either be the sum or the difference of the radio-frequency of the desired station and a desired intermediate frequency. For the Fig. 8 receiver, the mixing frequency is the sum. The desired
10 intermediate frequency is, say, 40 MHz in the case of FM-radio reception and, say, 10.7 MHz in the case of TV-reception. To give an example, if reception is desired of a TV station having a 210 MHz radio-frequency, the mixing frequency will have to be 250 MHz. To give another example, if reception is desired of a FM-radio station having an 89.3 Mhz radio frequency, the mixing frequency will have to be 100 MHz.

15 The mixing signal S_{mix} having the mixing frequency F_{mix} is obtained as follows. The oscillator OSC provides an oscillation signal S_{osc} at an oscillation frequency F_{osc} which may vary in a range between 1000 MHz and 2000 Mhz. The oscillation frequency F_{osc} is controlled by the phase-lock loop circuit PLL accordance with the control data CON and on the basis of the reference frequency F_{ref} which is,
20 for example, 4 MHz. The frequency divider DIV divides the oscillation signal S_{osc} with an adjustable frequency division factor N, to obtain the mixing signal S_{mix} . The adjustable division factor N may be any of the following values: 2,3,4,6,8,12 or 16. Thus, the Fig. 6 frequency diagram applies to both tuners TUN1, TUN2 of the Fig. 8 receiver. To give an example, there are three options to set the mixing frequency to 250
25 Mhz. The first option is $F_{\text{osc}} = 1000 \text{ MHz}$ and $N = 4$, the second option is $F_{\text{osc}} = 1500 \text{ MHz}$ and $N = 6$, and the third option is $F_{\text{osc}} = 2000 \text{ MHz}$ and $N = 8$.

 The following remarks are made with respect to the Fig. 8 receiver. There is no fixed relation between the oscillation frequency F_{osc} and bandpass filter centre frequencies in the radio-frequency input circuits RFIL, RFIM, RFIH. For
30 example, if reception is desired of a TV station having a radio frequency of 210 Mhz, the bandpass filters in the relevant radio-frequency input circuit will have be tuned to that radio frequency, whereas the oscillation frequency may either be 1000 MHz, 1500 MHz or 2000 MHz. It would be rather complicated and, hence, costly, if the tuning



voltages VT were derived from the a tuning voltage applied to the oscillator OSC, because the division factor N should be taken into account. Thus, the manner in which tuning voltages VT are generated in the Fig 8 receiver, is relatively cost-efficient.

Singapore patent applications 9600125.5, 9600123.5 and 9600124.3

5 (attorney's dockets PHN15647, PHN15648 and PHN15649, respectively) describe features which may optionally be used to implement the Fig. 8 receiver to advantage. The aforementioned applications are included herein by reference, as well as any corresponding applications.

Fig. 9 shows an example of a multimedia apparatus in accordance with
10 the invention. The Fig. 9 multimedia apparatus comprises a box BOX and a picture display device PDD. The box BOX houses various data processing circuits, not shown, and it houses an add-on card AOC with two tuners TUN1,TUN2 which are placed in a single shielded encasing SSE. The two tuners TUN1,TUN2 have radio frequency inlets I(TV) and I(FM) for receiving TV stations and FM-radio stations, respectively. The two
15 tunes TUN1,TUN2 may be implemented, for example, as shown Fig. 8. The two tuners TUN1,TUN2 allow concurrent display of, for example, two mutually different TV stations P1 and P2. Software for controlling the two tuners TUN1,TUN2 may be loaded in any type of memory which forms part of the multimedia device. Such software may be used, for example, to select an appropriate division factor for any frequency divider
20 DIV which is included in any of the two tuners TUN1 or TUN2 as shown in Fig. 8 for example.

The drawings and the above description thereof, illustrate rather than limit the invention. Evidently, there are numerous alternatives which fall within the scope of the appended Claims. To that respect, the following closing remarks are made.

25 There are numerous ways of physically spreading functions or functional elements over various units. In this respect, the drawings are very diagrammatic and respectively represent only one possible embodiment of the invention. Furthermore, the invention can be implemented by means of hardware comprising several distinct elements and, at least partially, by means of a suitably programmed computer.

30 Whilst the invention can be used to great advantage in multimedia apparatuses, applications in other types of apparatuses are by no means excluded. The invention may also be used to great advantage in, for example, TV sets, video tape recorders (VCRs) and in TV/VCR combinations. The invention may allow such



apparatuses to have features like, for example, PIP, Split Screen and separate Teletext.

Whilst examples were given of TV and FM-radio reception, other types of reception are by no means excluded. The invention may also be used for reception of, for example, broadband datacast.

5 Whilst examples were given of two merged tuners, more than two tuners may be merged into one module. In the latter case, it would be preferable if there were a greater choice in oscillation frequencies than illustrated in Fig. 6. This may be accomplished, for example, by providing more mutually different division factors or by increasing the oscillation frequency range, or both.

10 Whilst examples were given of binary and non-binary division factors, like 2,4,8,16 and 3,6,12, respectively, fractional division factors, like 1.5, may also be used. In the latter case, a filter is preferably coupled between the divider and the mixer. Fractional dividers generally provide signals having relatively asymmetrical duty cycles. As a result, mixer performance, in terms of noise and signal handling, may be
15 degraded. The filter will reduce any asymmetry in duty cycles and, consequently, will counter such degradation.

Any reference signs between parentheses shall not be construed as limiting the Claim concerned.



Claims.

1. A receiver comprising at least two tuners (TUN1,TUN2) for concurrent reception of mutually different signals, characterized in that the at least two tuners are merged into one module (MOD).
- 5 2. A receiver as claimed in Claim 1, characterized in that two tuners (TUN1,TUN2) each have an oscillator (OSC) coupled to a mixer (MIX) for converting a signal at a radio frequency to an intermediate frequency, and in that the oscillator of each of the two tuners has an oscillation frequency (Fosc1 or Fosc2) which does not coincide with the radio frequency (RF2 or RF1), or any sub-harmonic of the radio
10 frequency, of the signal received by the respective other tuner.
3. A receiver as claimed in Claim 2, characterized in that the oscillation frequency (Fosc1 or Fosc2) in at least one of the two tuners exceeds the highest possible radio frequency (RFmax2 or RFmax1) which the respective other tuner can
15 receive.
4. A receiver as claimed in Claim 2, characterized in that the difference (ΔF_{osc}) between the oscillation frequencies (Fosc1,Fosc2) in the two tuners exceeds an intermediate frequency bandwidth (BWIF).
- 20 5. A receiver as claimed in Claim 2, characterized in that at least one of two tuners has a frequency divider (DIV) which is coupled between the oscillator (OSC) and the mixer (MIX).
- 25 6. A receiver as claimed in Claim 5, characterized in that the frequency divider (DIV) has an adjustable division factor (N).
7. A receiver as claimed in Claim 5, characterized in that the mixer (MIX)





and the frequency divider (DIV) form part of an integrated circuit (MOIC).

8. A receiver comprising two tuners (TUN1,TUN2) for concurrent reception of mutually different signals, each of the two tuners having an oscillator (OSC) coupled to a mixer (MIX) for converting a signal at a radio frequency to an intermediate frequency, characterized in that the oscillator of each of the two tuners has an oscillation frequency (Fosc1 or Fosc2) which does not coincide with the radio frequency (RF2 or RF1), or any sub-harmonic of the radio frequency, of the signal received by the respective other tuner.
9. A method of concurrently receiving mutually different signals by means of at least two tuners (TUN1,TUN2) each of the at least two tuners having an oscillator (OSC) coupled to a mixer (MIX) for converting a signal at a radio frequency to an intermediate frequency, said method comprising the step of operating the oscillator of each of the at least two tuners at an oscillation frequency (Fosc1 or Fosc2) which does not coincide with the radio frequency (RF2 or RF1), or any sub-harmonic of the radio frequency, of the signal received by an other of the at least two tuners.
10. A multimedia apparatus comprising a receiver as claimed in Claim 1.
11. An add-on card (AOC) suitable for forming part of a multimedia apparatus, the add-on card comprising a receiver as claimed in Claim 1.
12. A single shielded encasing (SSE) comprising at least two tuners for concurrent reception of mutually different signals.



Abstract.

In a receiver, two tuners (TUN1,TUN2) allow concurrent reception of mutually different signals. The two tuners are merged into one module (MOD). This may give rise to mutual interference. However, there are various cost-efficient measures to counter any mutual interference. One such measure is that an oscillation frequency in
5 any of the two tuners does not coincide with the radio frequency, or any sub-harmonic of the radio frequency, of the signal received by the respective other tuner.

Fig. 1

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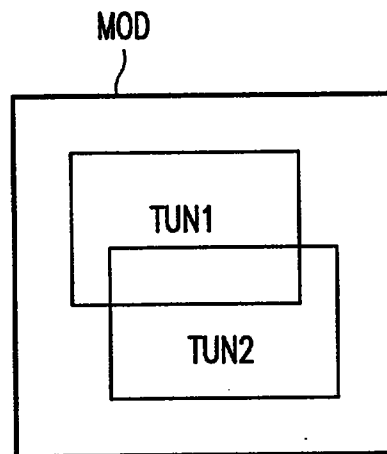


FIG. 1

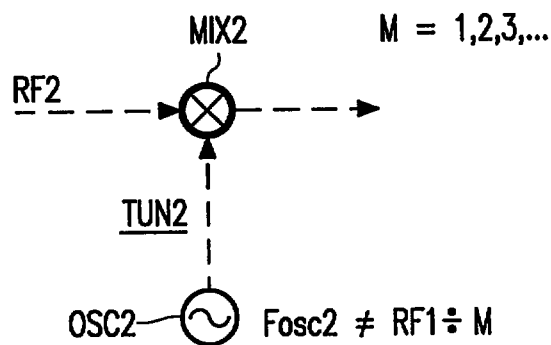
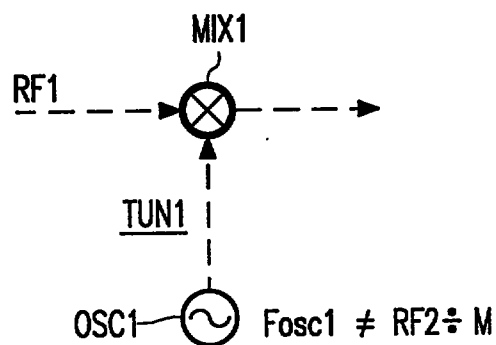


FIG. 2



2/6

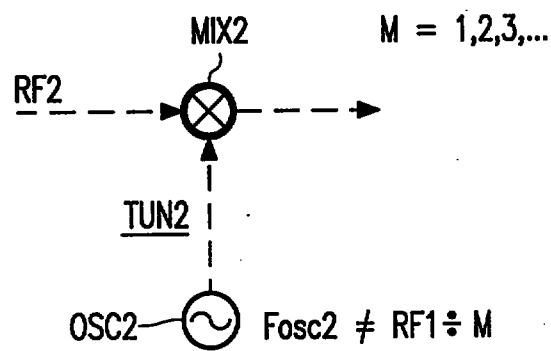
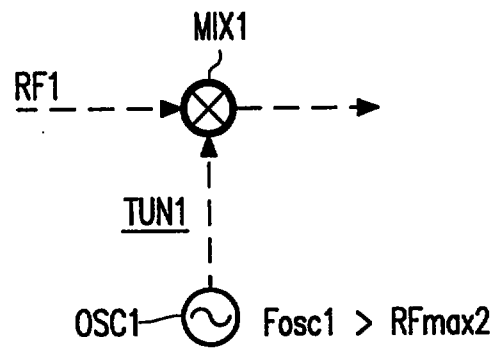


FIG. 3a

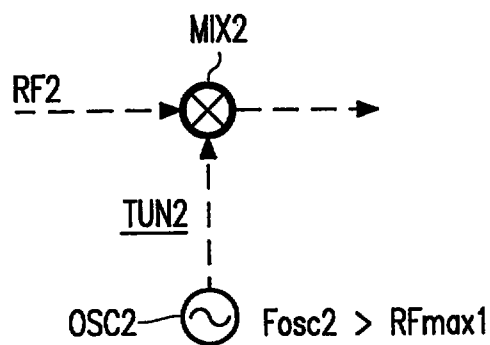
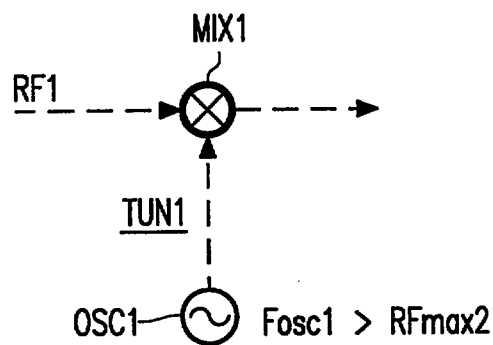


FIG. 3b



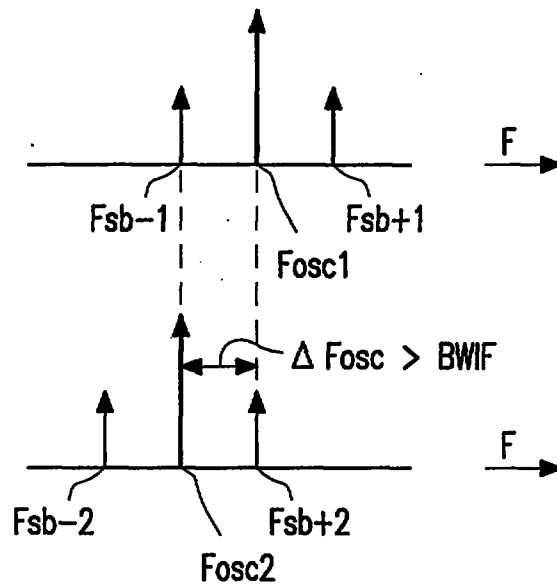


FIG. 4

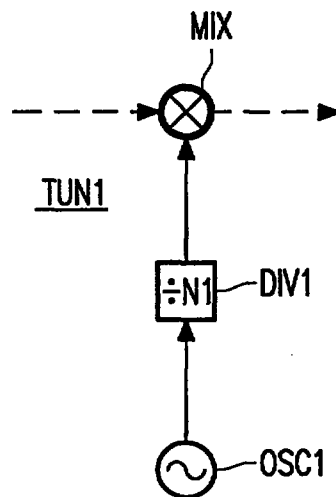


FIG. 5a

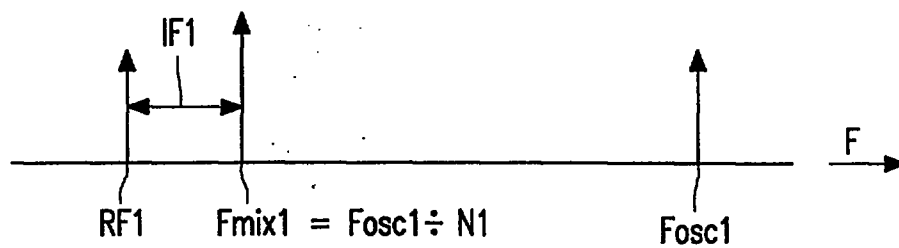


FIG. 5b



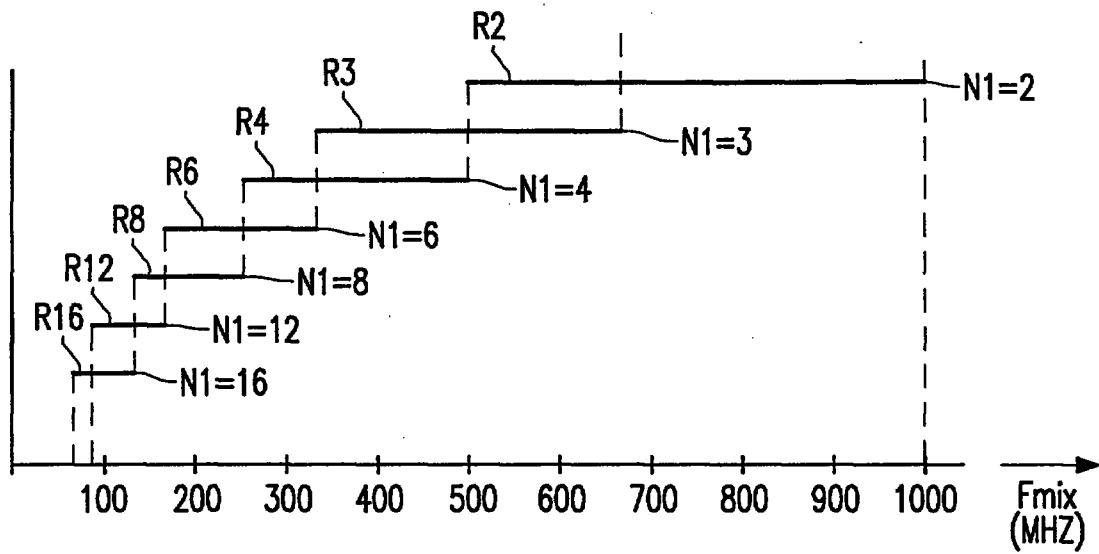


FIG. 6

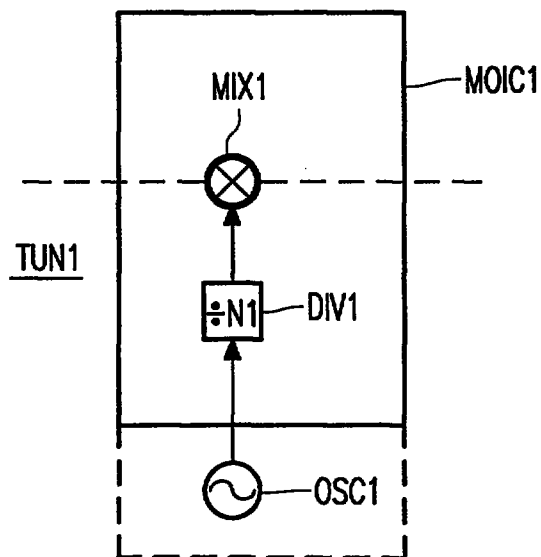


FIG. 7



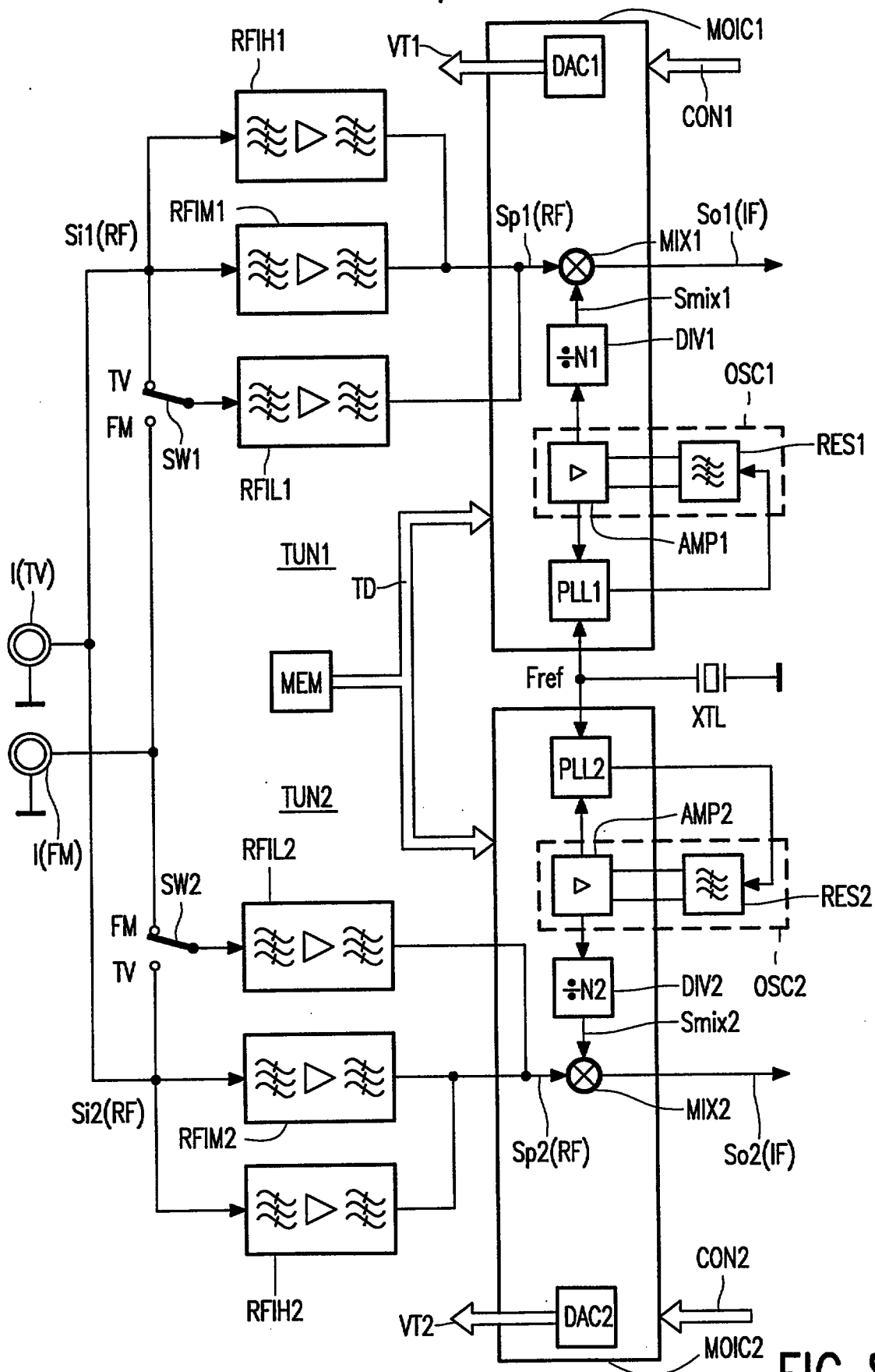


FIG. 8

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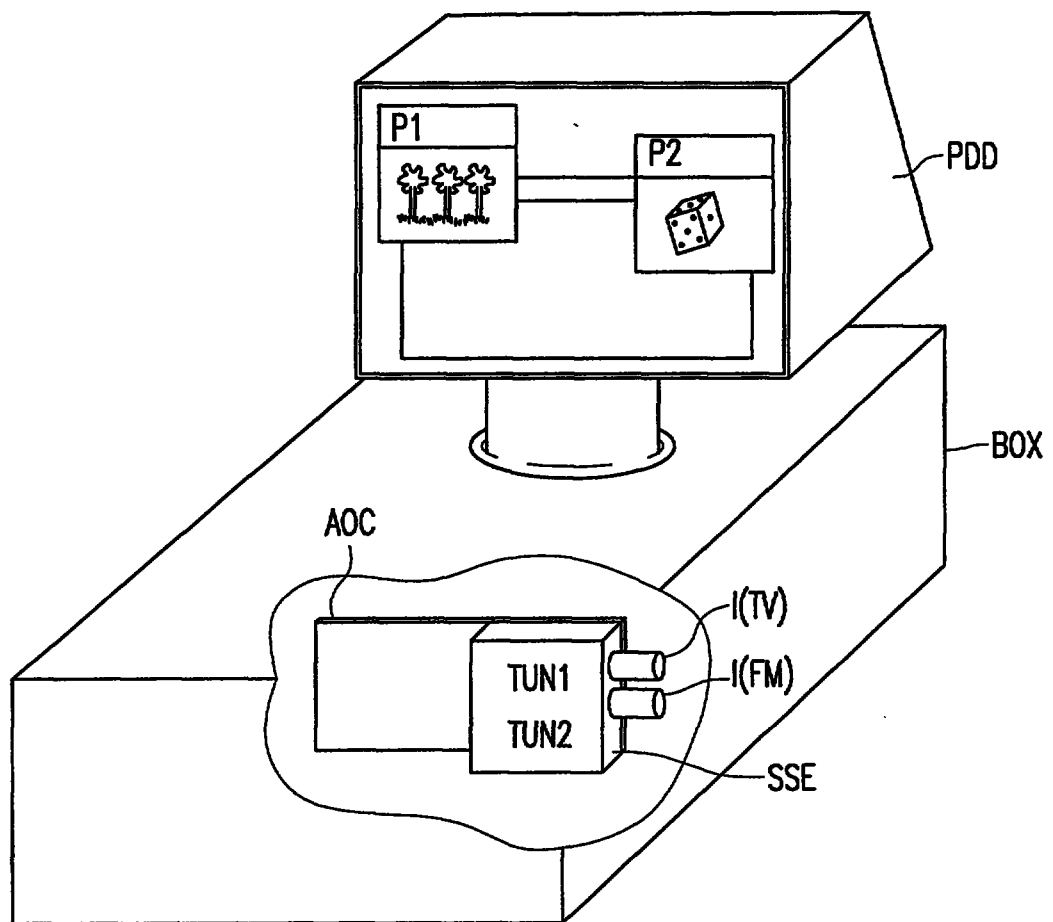


FIG. 9

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6-VI-PHN16175

Multi-tuner receiver.

REPLACEMENT SHEETS		SG
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☒	Claim(s) : paged 15 to paged 16	16
☒	Drawing(s) : paged 16 to paged 6/6	6/6
☒	Abstract : paged 17 to paged	
DATE OF RECEIPT		15 APR 1997

FIELD OF THE INVENTION

The invention relates to a receiver comprising at least two tuners for concurrent reception of mutually different signals. The invention also relates to a multimedia apparatus and an add-on card comprising such a receiver.

5 BACKGROUND ART

The Philips television (TV) set type 32PW9761 comprises two tuner modules for allowing a concurrent display of two mutually different TV programs. TV programs are broadcast at various respective radio frequencies in a range from, say, 45 MHz to 860 MHz. The broadcasted TV programs enter the TV set via a radio frequency inlet and are supplied to the two tuner modules via a splitter in the TV set. Each of the two tuner modules has a shielded encasing which houses an oscillator and a mixer for converting a radio frequency to an intermediate frequency of, say, 40 MHz. The respective oscillators have adjustable oscillation frequencies. An oscillation frequency determines which radio frequency, and therefore which broadcasted TV program, is converted to the 40 Mhz intermediate frequency for further processing so as to be displayed. If, for example, the oscillation frequency is 500 MHz, a TV program which is broadcast at a 460 MHz radio frequency, is converted to the 40 MHz intermediate frequency and, consequently, may be displayed.

20 SUMMARY OF THE INVENTION

The invention seeks, inter alia, to provide a receiver of the subject type which, with respect to the background art, allows more cost-efficient implementations. Claims 1 and 8 define receivers in accordance to the invention. Claims 9, 10, 11 and 12 respectively define a method of receiving, a multimedia apparatus, an add-on card and a single shielded encasing, all in accordance with the invention. Additional features, which may optionally be used to implement the invention to advantage, are defined in the dependent Claims.

The invention takes the following aspects into consideration. Up to the

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present, the demand for receivers which can concurrently receive mutually different signals, has been relatively low. To give an example, of the total number of TV sets sold, only a relatively small percentage has two tuners to allow, for example, a picture-in-picture (PIP) functionality. For that reason, it currently is cost-efficient to implement

5 PIP TV sets in a background-art manner. That is, two separate tuner modules are used which are individually also applicable in many other types of TV sets and, therefore, are produced in relatively large quantities and, therefore, are relatively cheap.

However, the situation may be different in the future. The amount of information and entertainment offered to consumers is increasing rapidly. With that, the

10 variety of ways in which information and entertainment is offered, is also increasing. For example, it may be transmitted in an analog or digital form via satellite, cable TV networks, telephone networks, et cetera. Furthermore, multimedia tends to centralize various types of information like text, data, audio and visual information. In view of the aforementioned, the demand for receivers which can concurrently receive mutually

15 different signals, may increase to such a level, that other solutions than the background-art solution may be more cost-efficient.

In accordance with the invention, two or more tuners are merged into one module. If the two or more tuners are merged, various components may be shared by the two or more tuners like, for example, crystals, integrated circuits, printed wire

20 boards, metal ware, connectors, and pin blocks. Costs which will be saved if various components are shared, may outweigh costs related to merging the two or more tuners into one module, once the demand for receivers of the subject type is sufficiently high.

The invention and additional features, which may optionally be used to implement the invention to advantage, will be apparent from and elucidated with

25 reference to the drawings described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

30 Fig. 1 is a conceptual diagram illustrating the basic principles of the invention;

Fig. 2 to 7 are diagrams illustrating additional features which may optionally be used to implement the invention to advantage;

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Fig. 8 is a block schematic diagram of an example of a receiver in accordance to the invention; and

Fig. 9 is a diagram illustrating an example of a multimedia apparatus in accordance with the invention.

5

DETAILED DESCRIPTION OF THE DRAWINGS

First, some remarks are made on the use of reference signs. Similar
10 entities will be denoted with an identical lettercode throughout the drawings. In a single drawing, various similar entities may be shown. In that case, a numeral will be added to the lettercode, to distinguish similar entities from each other. Furthermore, if an entity forms part of a higher entity, the numeral in the reference sign of the entity will indicate that it belongs to the higher entity which has the same numeral in its reference
15 sign. In the description, and in the claims, any numeral in a reference sign may be omitted if this is appropriate.

Fig. 1 illustrates the basic principle of the invention. In Fig. 1, at least two tuners TUN1, TUN2 are merged into one module MOD. Although Fig. 1 shows two tuners TUN1, TUN2, further tuners may be merged into the same module MOD.

20 Fig. 2 illustrates that each of the two tuner TUN1, TUN2 has an oscillator OSC coupled to a mixer MIX for converting a signal at a radio frequency to an intermediate frequency. Fig. 2 also illustrates the following additional feature. The oscillator of each of the two tuners has an oscillation frequency, Fosc1 or Fosc2, which does not coincide with the radio frequency, RF2 or RF1 respectively, or any
25 sub-harmonic of the radio frequency, of the signal received by the respective other tuner. This preferably applies substantially throughout respective tuning ranges of the two tuners TUN1, TUN2.

The Fig. 2 feature is based on the following considerations. The two tuners TUN1, TUN2 which are merged into one module may mutually interfere each
30 other. In particular, the oscillator of one of the two tuners, may interfere with the signal received by the respective other tuner. An oscillator signal may propagate to various points in the receiver in many different ways. For example, it may propagate by means of induction in metal parts and by means of crosstalk into printed wire board tracks

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which carry, for example, switching signals and varicap voltages. The overall propagation attenuation which the oscillator signal experiences, is often highly unpredictable and, moreover, it may vary strongly as a function of frequency. This is an important fact, since the oscillator signal may not only comprise a fundamental
5 frequency component but also harmonic frequency components as well. The amplitude of an harmonic frequency component may therefore be higher than that of the fundamental frequency component at certain points in the receiver.

There are various ways to counter the above described mutual interference. One solution could be to keep oscillator signals at sufficiently low levels.
10 However, if an oscillator signal level is reduced, this will generally degrade performance in terms of noise and frequency stability.

An other solution could be to electro-magnetically shield the oscillators. However, shielding is relatively expensive and, in some cases, it may even be insufficiently effective. The following example is given as an illustration. In TV
15 reception, an interference distance of at least 60 dB is desirable. Assuming that the level of a TV signal received by a tuner is 1 mV, which is a typical, the level of an interfering signal may not exceed 1 μ V. Assuming that the level of the oscillator signal in an other tuner is 1 V, which is typical, a 120 dB attenuation is needed between the two tuners. If the two tuners are merged into one module, any internal shielding for
20 providing such attenuation, if feasible at all, will be costly and, moreover, difficult to design.

Yet another solution could be to block reception for radio-frequency combinations at which the two tuners TUN1, TUN2 would mutually interfere. This may be achieved by means of, for example, a suitably programmed computer which controls
25 the two tuners TUN1, TUN2. However, as also harmonic frequency components of oscillator signals need to be taken into account, it may be needed to block reception for relative many radio-frequency combinations. In that case, end users will be stuck with a relatively constrained variety of signals which can be concurrently received.

If the Fig. 2 feature is applied, neither the fundamental frequency
30 component nor any harmonic frequency component of an oscillator signal in any of the two tuners TUN1 or TUN2, will directly interfere with the signal being received by the respective other tuner, TUN2 or TUN1, respectively. The oscillators OSC1, OSC2 are therefore allowed to operate at signal levels which provide satisfactory performance in

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terms of noise and stability. What is more, this does neither require relatively elaborate shielding nor blocking reception for relatively many radio-frequency combinations. Thus, the Fig. 2 feature contributes to quality and versatility of reception and cost-efficiency, either in combination or as such.

5 The Fig. 2 feature will provide an additional advantage, if a splitter is used to apply signals to the two tuners TUN1, TUN2 from a common terminal. In that case, the splitter need not provide high attenuation between the two tuners TUN1, TUN2 in order to prevent mutual interference. For that reason, the splitter may be realized with relatively few active components, or it may even be realized without any active
10 components. Active components consume power and produce noise and distortion. Thus, the Fig. 2 feature allows a relatively power-efficient, noiseless and distortionless splitter. It should be noted that these advantages will also be obtained, if two tuners are separate, as in the background art.

 Fig. 3a illustrates the following additional feature. The oscillation
15 frequency F_{osc1} in tuner TUN1 exceeds the highest possible radio frequency RF_{max2} which tuner TUN2 can receive. This preferably applies substantially throughout the tuning range of the tuner TUN1.

 The Fig. 3a feature is based on the following considerations. If the tuner TUN1 needs to be tunable throughout a relatively wide tuning range, it may be difficult
20 to avoid coincidence of the oscillation frequency F_{osc1} with the radio frequency $RF2$, or any sub-harmonic of the radio frequency $RF2$, of the signal received by tuner TUN2. Relatively complicated and, hence, costly measures may be needed to avoid such coincidence. However, if the Fig. 3a feature is applied, any such coincidence will be excluded by definition. Thus, the Fig. 3a feature contributes to cost-efficiency, in
25 particular if the tuner TUN1 needs to be tuned throughout a relatively wide tuning range.

 Fig. 3b illustrates the following additional feature. The oscillation frequency, F_{osc1} or F_{osc2} , in each of the two tuners exceeds the highest possible radio frequency, RF_{max2} or RF_{max1} , respectively, which the respective other tuner can
30 receive. The Fig. 3b feature is effectively an addition to the Fig. 3a feature. The addition is that the oscillation frequency F_{osc2} in tuner TUN2 also exceeds the highest possible radio frequency RF_{max1} which tuner TUN1 can receive. Thus, the Fig. 3b feature contributes to cost-efficiency, in particular if the two tuners TUN1, TUN2 both

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need to be tuned throughout a relatively wide tuning range.

The following remarks are made with respect to the Figs. 3a and 3b features. When the Fig. 3a feature is applied, provisions may be made that the tuner TUN1 receives the signal with the lower radio frequency and that, consequently, the tuner TUN2 receives the signal with the higher radio frequency. If, in addition, the oscillation frequency Fosc2 in the tuner TUN2 is located above the radio frequency RF2 of the signal received by this tuner, it will for sure exceed the radio frequency RF1 of the signal received by the tuner TUN1. The overall result will be that the oscillation frequency Fosc1 or Fosc2 in each of the two tuners will exceed the radio frequency RF2 or RF1, respectively, received by the other tuner. Consequently, neither fundamental components nor any harmonic components of the oscillation signals can interfere with the signals received. Thus, the Fig. 3a feature can provide advantages similar to those of the Fig. 3b feature.

Notwithstanding that what is mentioned above, the Fig. 3b feature may be preferable over the Fig. 3a feature for the following reason. Assume that two signals S(X) and S(Y) are concurrently received. The signal S(Y) has a higher radio frequency than signal S(X). The reception signal S(Y) needs to be discontinued in favour of an other signal S(Z) which has a lower radio frequency than S(X). The following will happen in the case of Fig. 3a with the provisions as described above. The tuner TUN2 will have to take over the reception of signal S(X), which is maintained, from the tuner TUN1. Such a take-over is needed in view of the higher-lower radio frequency relation. The take-over may cause an interruption in reception of signal S(X). In contradistinction, any take-over will not be needed if the Fig. 3b feature is applied. Thus, the Fig. 3b feature allows an uninterrupted reception while changing any concurrent reception.

Fig. 4 illustrates the following additional feature. The difference ΔF_{osc} between the oscillation frequencies Fosc1, Fosc2 in the two tuners TUN1, TUN2, exceeds an intermediate frequency bandwidth BWIF. This preferably applies substantially throughout the respective tuning ranges of the two tuners TUN1, TUN2.

The Fig. 4 feature is based on the following considerations. The oscillators OSC1, OSC2 may mutually phase modulate each other as a result of mutual electro-magnetic coupling. This will cause the oscillator signals to have sidebands. Fig. 4 shows sidebands Fsb+1, Fsb-1 belonging to oscillator OSC1 and sidebands

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Fsb+2,Fsb-2 belonging to oscillator OSC2. The sidebands are located at $+\Delta F_{osc}$ and $-\Delta F_{osc}$ from the oscillation frequencies Fosc1,Fosc2. The sidebands of each oscillator signal will mix with the respective signal received. As a result, the signals received which have been converted to the respective intermediate frequencies, will also have
5 sidebands located at $+\Delta F_{osc}$ and $-\Delta F_{osc}$ from these respective intermediate frequencies.

If the Fig. 4 feature is applied, the aforementioned sidebands will not directly interfere with the respective signal received. Thus, the Fig. 4 feature counters mutual interference between the two tuners TUN1,TUN2 which may arise as a result of
10 mutual electromagnetic coupling of their oscillators. Consequently, there will be relatively little need to counter such mutual electro-magnetic coupling with measures as, for example, providing internal shielding or improving the quality Q of an oscillator tank circuit. Such measures are relatively costly, in particular at relatively high frequencies. Hence, the Fig. 4 feature contributes to cost-efficiency.

15 The following additional remarks are made with respect to the Fig. 4 feature. The sidebands Fsb+ ,Fsb- could cause intermodulation products which may harm reception. However, the respective sidebands will generally have such a small amplitude that, in many cases, this form of mutual interference may be neglected. Furthermore, the amplitude of the respective sidebands Fsb+ ,Fsb- will decrease, if the
20 difference ΔF_{osc} between the oscillator frequencies Fosc1,Fosc2 increases.

When one of the two tuners TUN1,TUN2 is operated in an auto search mode, it may be advantageous to skip a frequency range where mutual phase modulation can occur e.g. by measures in software. To that respect it should also be noted that any harmonics of the oscillation frequencies Fosc1,Fosc2, do not substantially
25 contribute to any mutual phase modulation of the oscillators OSC1,OSC2. Thus, there will be little or no mutual phase modulation if one of the oscillator frequencies, Fosc1 or Fosc2, is relatively close to an harmonic of the other oscillator frequency, Fosc2 or Fosc1, respectively. Consequently, if the frequency ranges of the oscillators OSC1,OSC2 do not overlap, any skip during an auto search will not be necessary.

30 Fig. 5a illustrates the following additional feature. A frequency divider DIV1 is coupled between the oscillator OSC1 and the mixer MIX1 in the tuner TUN1. Before any advantages of this feature are discussed, the following should be noted. The frequency divider DIV1 generates a sub-harmonic of the oscillator signal. In principle,

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the sub-harmonic may interfere with the signal received by the tuner TUN2, not shown in Fig. 5a. Thus, the divider DIV1 as well as circuitry coupling it to mixer MIX1, should be regarded as a potentially interfering transmitters. However, with proper design, these potentially interfering transmitters will be appreciably weaker than the potentially interfering transmitter which the oscillator OSC1 would have been if the invention were not used. Consequently, the Fig. 5a feature does not withstand a merging of two tuners in a manner which would not have been possible in the background art.

An advantage of the Fig. 5a feature will be explained with reference to Fig. 5b. Fig. 5b is a frequency diagram showing the radio frequency RF1, the oscillation frequency Fosc1, and a mixing frequency Fmix1. The mixing frequency Fmix is the oscillation frequency Fosc1 divided by N1, N1 being the division factor of the frequency divider DIV1. Fig. 5b also shows the intermediate frequency IF1 which is the difference between the mixing frequency Fmix1 and the radio frequency RF1.

Assuming that the intermediate frequency IF1 preferably has a certain desired value, for example 40 MHz in the case of TV reception, an advantage of the Fig. 5a feature is as follow. It allows the oscillation frequency Fosc1 to be such that mutual interference between the two tuners TUN1, TUN2, as described in the foregoing, can be countered by a suitable choice of the division factor N1 of the frequency divider DIV1. If, in addition, a frequency divider is also coupled between the oscillator OSC2 and the mixer MIX2 in the tuner TUN2, all shown in Fig. 1, this will provide a greater number of possibilities to counter mutual interference. The division factor of the last mentioned divider introduces, as it were, an extra measure of freedom to achieve this.

The following additional remarks are made with respect to the Fig. 5a feature. The Fig. 5a feature is neither essential to the invention, nor is it essential to any of the other features described above. The oscillation frequency Fosc1, shown in Fig. 5b, may be directly applied to the mixer MIX1 without any frequency division. However, in that case the intermediate frequency would be the difference between the oscillation frequency Fosc1 and the radio frequency RF1. Consequently, the intermediate frequency would be higher. Circuitry for processing relatively high intermediate frequency signals is relatively costly, power-consuming and/or critical. Consequently, because the Fig. 5a feature allows a relatively low intermediate frequency, it contributes cost-efficiency, power-efficiency and robustness.

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Fig. 6 illustrates the following additional feature. The division factor $N1$ of the frequency divider $DIV1$, shown in Fig. 5a, is adjustable. Fig. 6 shows various mixing frequency ranges $R2, R3, R4, R6, R8, R12, R16$ obtained with division factors $N1=2, 3, 4, 6, 8, 12, 16$, respectively, if the oscillator $OSC1$ is tunable between 1000 and 2000 MHz. Thus, if the frequency divider $DIV1$ can be adjusted to have any of these division factors, it allows mixing frequencies throughout a range extending from 62.5 MHz to 1000 MHz. If, however, the division factor $N1$ were fixed, the oscillator $OSC1$ would have to be tunable over a wider range, to allow a similar choice of mixing frequencies. This would make it more difficult, or even impossible, to realize the oscillator $OSC1$. As a solution, several tunable oscillators could be used, each tunable oscillator covering a certain portion of the range of mixing frequencies. This solution is common in TV where, for example, oscillators are used for the bands VHF-low, VHF-high and UHF, respectively. The Fig. 6 feature, however, allows tuning throughout a relatively wide frequency range with a single oscillator which needs only to be tuned over a relatively narrow frequency range. Consequently, the Fig. 6 feature contributes to cost-efficiency.

Fig. 6 also illustrates the following advantageous additional feature. Over a substantial portion of the range of mixing frequencies, namely between 83.33 MHz and 666.67 Mhz, there is more than one oscillator frequency with which a certain mixing frequency can be obtained. In other words, for a certain mixing frequency, there is a choice of oscillator frequencies. This choice allows the oscillator frequency $Fosc1$ in the tuner $TUN1$ to be relatively distant from the oscillator frequency $Fosc2$ in the tuner $TUN2$, thereby countering mutual interference. To that effect, it does not matter if the oscillators $OSC1, OSC2$ operate in respective frequency ranges which overlap. A suitably chosen division factor $N1$ can prevent the oscillators $OSC1, OSC2$ from being too close in frequency. Moreover, if an adjustable frequency divider is also coupled between the oscillator $OSC2$ and the mixer $MIX2$ in tuner $TUN2$, there will be an even greater choice in keeping the oscillation frequencies $Fosc1, Fosc2$ apart. Suitable software may be used to choose the optimal division factor, or division factors, in a certain case.

In Fig. 6, two frequency ranges remain for which no choice in oscillation frequency exist, namely a frequency range below 83.33 MHz and a frequency range above 666.67 Mhz. Although it would be advantageous if there were a choice within

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these frequency ranges, any absence of choice will in most cases not lead to a noticeable mutual interference. First of all, two tuners generally need not concurrently receive at the same radio frequency or almost the same radio frequency, in which case the oscillation frequencies F_{osc1}, F_{osc2} would coincide or nearly coincide, respectively.

5 Furthermore, it hardly occurs that two adjacent radio-frequency channels are occupied by usable signals and, therefore, the need for simultaneous reception at two adjacent radio-frequency channels is very slim. In the unlikely event that such reception is needed, the oscillation frequencies F_{osc1}, F_{osc2} will be spaced apart by an amount which is N times the distance between the two adjacent radio-frequency channels, N

10 being the identical division factor of the dividers $DIV1, DIV2$. Thus, because the oscillation frequencies F_{osc1}, F_{osc2} are divided, they will be relatively spaced apart such that any sidebands, as a result of mutual phase modulation, will fall outside the intermediate frequency bandwidth, even if an identical division factor is used.

Fig. 7 illustrates the following additional feature. The mixer $MIX1$ and

15 the frequency divider $DIV1$ form part of an integrated circuit $MOIC1$. Hence, the circuitry carrying the sub-harmonic $F_{osc1} \div N1$ of the oscillation signal, has a small geometry. As a result, any radiation of the sub-harmonic $F_{osc1} \div N1$, which may potentially interfere with the signal received by the tuner $TUN2$, will be relatively modest. Consequently, the Fig. 7 feature enhances the extent to which the two tuners

20 $TUN1, TUN2$ may be merged.

The following additional remarks are made with respect to the Fig. 7 feature. First of all, the mixer $MIX1$ is preferably implemented in the form of a balanced circuit. This provides inherent suppression of any oscillator sub-harmonic residues at input and output ports of the mixer circuit $MIX1$. Preferably, the divider

25 $DIV1$ is also implemented in the form of a balanced circuit. Secondly, it should be noted that the integrated circuit $MOIC1$ may comprise further circuits. The dotted lines in Fig. 7 illustrate that the oscillator $OSC1$ may wholly or partially be included in the integrated circuit $MOIC1$. If the tuner $TUN2$ also comprises a frequency divider coupled between the mixer $MIX2$ and the oscillator $OSC2$, these circuits may also form

30 part of the integrated circuit $MOIC1$. As an other example, the integrated circuit $MOIC1$ may also include a phase-lock loop circuit.

Fig. 8 shows an example of a receiver in accordance with the invention and including the Figs. 2 to 7 additional features. The Fig. 8 receiver is a dual TV/FM

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receiver capable of concurrently receiving two mutually different TV stations, or two mutually different FM-radio stations, or a TV station and an FM-radio station. To that end, it comprises two tuners TUN1, TUN2 for concurrently converting two mutually different radio-frequency signals $Si1(RF)$ and $Si2(RF)$ to intermediate frequency signals $So1(IF)$ and $So2(IF2)$, respectively. Any of the radio-frequency signals $Si1(RF)$ and $Si2(RF)$ may either be a TV station or an FM-radio station, received at radio-frequency inlets I(TV) and I(FM), respectively.

In Fig. 8, each of the two tuners TUN1, TUN2 includes a switch SW, three radio-frequency input circuits RFIL, RFIM and RFIH, and an integrated circuit MOIC. Radio-frequency input circuits RFIL, RFIM and RFIH are arranged for processing signals within a VHF-low band, a VHF-high band and a UHF band, respectively. Each of the integrated circuits MOIC houses a mixer MIX, a divider DIV and an amplifier portion AMP of an oscillator OSC. A resonator portion RES of the oscillator OSC is external to the integrated circuit MOIC. Each of the integrated circuits MOIC further houses a phase-lock loop circuit PLL and a digital-to-analog conversion arrangement DAC. The two tuners TUN1, TUN2 share a memory circuit MEM and a crystal XTL which resonates at a reference frequency F_{ref} .

Each of the two tuners TUN1, TUN2 operates as follows. The switch SW is set to a position TV or a position FM depending on whether reception of a TV station or an FM-radio station is desired. In the first case, a radio frequency signal $Si(RF)$ may be processed in any of the three radio-frequency input circuits RFIL, RFIM or RFIH. In the latter case, that of FM-radio reception, the radio-frequency signal $Si(RF)$ is processed by the radio frequency input circuit RFIL for the VHF-low band. In any case, the relevant radio-frequency input circuit supplies a suitably processed radio-frequency signal $Sp(RF)$ to the mixer MIX in the integrated circuit MOIC.

The radio-frequency input circuits RFIL, RFIM and RFIH comprise tunable bandpass filters which are not shown for reasons of conciseness. Tuning voltages VT, which control the tunable bandpass filters, are obtained as follows. Control data CON, which comprises information on the desired radio-frequency, effectively selects which tuning data TD is read from the memory MEM for supply to the digital-to-analog converter arrangement DAC. The selected tuning data TD is such that the digital-to-analog conversion arrangement DAC provides the tuning voltages VT for which the relevant radio-frequency input circuits suitably processes the desired

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radio-frequency signal $S_i(\text{RF})$. Accordingly, with appropriate tuning data stored in the memory MEM, the bandpass filters may satisfactorily be tuned throughout the VHF-low, VHF-high and UHF bands. Any aberrations in the tuning of the bandpass filters relative to each other may be reduced by means of a manual adjustment.

5 The mixer MIX in the integrated circuit MOIC effectively multiplies the suitably processed radio-frequency signal $S_p(\text{RF})$ with a mixing signal S_{mix} having a mixing frequency F_{mix} . In principle, the mixing frequency may either be the sum or the difference of the radio-frequency of the desired station and a desired intermediate frequency. For the Fig. 8 receiver, the mixing frequency is the sum. The desired
10 intermediate frequency is, say, 40 MHz in the case of FM-radio reception and, say, 10.7 MHz in the case of TV-reception. To give an example, if reception is desired of a TV station having a 210 MHz radio-frequency, the mixing frequency will have to be 250 MHz. To give another example, if reception is desired of a FM-radio station having an 89.3 Mhz radio frequency, the mixing frequency will have to be 100 MHz.

15 The mixing signal S_{mix} having the mixing frequency F_{mix} is obtained as follows. The oscillator OSC provides an oscillation signal S_{osc} at an oscillation frequency F_{osc} which may vary in a range between 1000 MHz and 2000 Mhz. The oscillation frequency F_{osc} is controlled by the phase-lock loop circuit PLL accordance with the control data CON and on the basis of the reference frequency F_{ref} which is,
20 for example, 4 MHz. The frequency divider DIV divides the oscillation signal S_{osc} with an adjustable frequency division factor N , to obtain the mixing signal S_{mix} . The adjustable division factor N may be any of the following values: 2,3,4,6,8,12 or 16. Thus, the Fig. 6 frequency diagram applies to both tuners TUN1, TUN2 of the Fig. 8 receiver. To give an example, there are three options to set the mixing frequency to 250
25 Mhz. The first option is $F_{\text{osc}} = 1000 \text{ MHz}$ and $N = 4$, the second option is $F_{\text{osc}} = 1500 \text{ MHz}$ and $N = 6$, and the third option is $F_{\text{osc}} = 2000 \text{ MHz}$ and $N = 8$.

 The following remarks are made with respect to the Fig. 8 receiver. There is no fixed relation between the oscillation frequency F_{osc} and bandpass filter centre frequencies in the radio-frequency input circuits RFIL, RFIM, RFIH. For
30 example, if reception is desired of a TV station having a radio frequency of 210 Mhz, the bandpass filters in the relevant radio-frequency input circuit will have be tuned to that radio frequency, whereas the oscillation frequency may either be 1000 MHz, 1500 MHz or 2000 MHz. It would be rather complicated and, hence, costly, if the tuning

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voltages VT were derived from the a tuning voltage applied to the oscillator OSC, because the division factor N should be taken into account. Thus, the manner in which tuning voltages VT are generated in the Fig 8 receiver, is relatively cost-efficient.

Singapore patent applications 9600125.5, 9600123.5 and 9600124.3

- 5 (attorney's dockets PHN15647, PHN15648 and PHN15649, respectively) describe features which may optionally be used to implement the Fig. 8 receiver to advantage. The aforementioned applications are included herein by reference, as well as any corresponding applications.

- Fig. 9 shows an example of a multimedia apparatus in accordance with
10 the invention. The Fig. 9 multimedia apparatus comprises a box BOX and a picture display device PDD. The box BOX houses various data processing circuits, not shown, and it houses an add-on card AOC with two tuners TUN1,TUN2 which are placed in a single shielded encasing SSE. The two tuners TUN1,TUN2 have radio frequency inlets I(TV) and I(FM) for receiving TV stations and FM-radio stations, respectively. The two
15 tunes TUN1,TUN2 may be implemented, for example, as shown Fig. 8. The two tuners TUN1,TUN2 allow concurrent display of, for example, two mutually different TV stations P1 and P2. Software for controlling the two tuners TUN1,TUN2 may be loaded in any type of memory which forms part of the multimedia device. Such software may be used, for example, to select an appropriate division factor for any frequency divider
20 DIV which is included in any of the two tuners TUN1 or TUN2 as shown in Fig. 8 for example.

The drawings and the above description thereof, illustrate rather than limit the invention. Evidently, there are numerous alternatives which fall within the scope of the appended Claims. To that respect, the following closing remarks are made.

- 25 There are numerous ways of physically spreading functions or functional elements over various units. In this respect, the drawings are very diagrammatic and respectively represent only one possible embodiment of the invention. Furthermore, the invention can be implemented by means of hardware comprising several distinct elements and, at least partially, by means of a suitably programmed computer.

- 30 Whilst the invention can be used to great advantage in multimedia apparatuses, applications in other types of apparatuses are by no means excluded. The invention may also be used to great advantage in, for example, TV sets, video tape recorders (VCRs) and in TV/VCR combinations. The invention may allow such

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apparatuses to have features like, for example, PIP, Split Screen and separate Teletext.

Whilst examples were given of TV and FM-radio reception, other types of reception are by no means excluded. The invention may also be used for reception of, for example, broadband datacast.

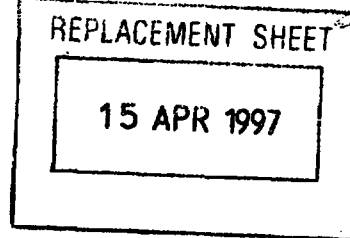
5 Whilst examples were given of two merged tuners, more than two tuners may be merged into one module. In the latter case, it would be preferable if there were a greater choice in oscillation frequencies than illustrated in Fig. 6. This may be accomplished, for example, by providing more mutually different division factors or by increasing the oscillation frequency range, or both.

10 Whilst examples were given of binary and non-binary division factors, like 2,4,8,16 and 3,6,12, respectively, fractional division factors, like 1.5, may also be used. In the latter case, a filter is preferably coupled between the divider and the mixer. Fractional dividers generally provide signals having relatively asymmetrical duty cycles. As a result, mixer performance, in terms of noise and signal handling, may be
15 degraded. The filter will reduce any asymmetry in duty cycles and, consequently, will counter such degradation.

Any reference signs between parentheses shall not be construed as limiting the Claim concerned.

Claims.

1. A receiver comprising at least two tuners (TUN1,TUN2) for concurrent reception of mutually different signals, characterized in that the at least two tuners are merged into one module (MOD).
- 5 2. A receiver as claimed in Claim 1, characterized in that two tuners (TUN1,TUN2) each have an oscillator (OSC) coupled to a mixer (MIX) for converting a signal at a radio frequency to an intermediate frequency, and in that the oscillator of each of the two tuners has an oscillation frequency (Fosc1 or Fosc2) which does not
10 frequency, of the signal received by the respective other tuner.
3. A receiver as claimed in Claim 2, characterized in that the oscillation frequency (Fosc1 or Fosc2) in at least one of the two tuners exceeds the highest possible radio frequency (RFmax2 or RFmax1) which the respective other tuner can
15 receive.
4. A receiver as claimed in Claim 2, characterized in that the difference (ΔF_{osc}) between the oscillation frequencies (Fosc1,Fosc2) in the two tuners exceeds an intermediate frequency bandwidth (BWIF).
20
5. A receiver as claimed in Claim 2, characterized in that at least one of two tuners has a frequency divider (DIV) which is coupled between the oscillator (OSC) and the mixer (MIX).
- 25 6. A receiver as claimed in Claim 5, characterized in that the frequency divider (DIV) has an adjustable division factor (N).



and the frequency divider (DIV) form part of an integrated circuit (MOIC).

8. A receiver comprising two tuners (TUN1,TUN2) for concurrent reception of mutually different signals, each of the two tuners having an oscillator (OSC) coupled to a mixer (MIX) for converting a signal at a radio frequency to an intermediate frequency, characterized in that the oscillator of each of the two tuners has an oscillation frequency (Fosc1 or Fosc2) which does not coincide with the radio frequency (RF2 or RF1), or any sub-harmonic of the radio frequency, of the signal received by the respective other tuner.
- 10
9. A method of concurrently receiving mutually different signals by means of at least two tuners (TUN1,TUN2) each of the at least two tuners having an oscillator (OSC) coupled to a mixer (MIX) for converting a signal at a radio frequency to an intermediate frequency, said method comprising the step of operating the oscillator of each of the at least two tuners at an oscillation frequency (Fosc1 or Fosc2) which does not coincide with the radio frequency (RF2 or RF1), or any sub-harmonic of the radio frequency, of the signal received by an other of the at least two tuners.
- 15
10. A multimedia apparatus comprising a receiver as claimed in Claim 1.
- 20
11. An add-on card (AOC) suitable for forming part of a multimedia apparatus, the add-on card comprising a receiver as claimed in Claim 1.
12. A single shielded encasing (SSE) comprising at least two tuners for concurrent reception of mutually different signals.
- 25

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MULTI-TUNER RECEIVER

In a receiver, two tuners (TUN1,TUN2) allow concurrent reception of mutually different signals. The two tuners are merged into one module (MOD). This may give rise to mutual interference. However, there are various cost-efficient measures to counter any mutual interference. One such measure is that an oscillation frequency in
5 any of the two tuners does not coincide with the radio frequency, or any sub-harmonic of the radio frequency, of the signal received by the respective other tuner.

Fig. 1

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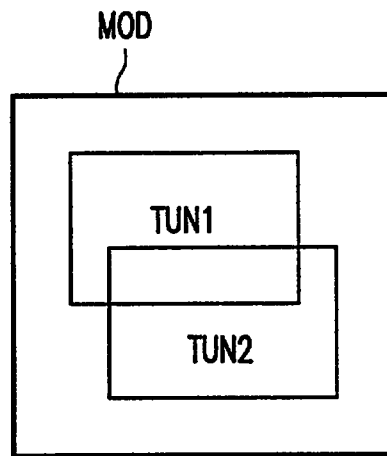


FIG. 1

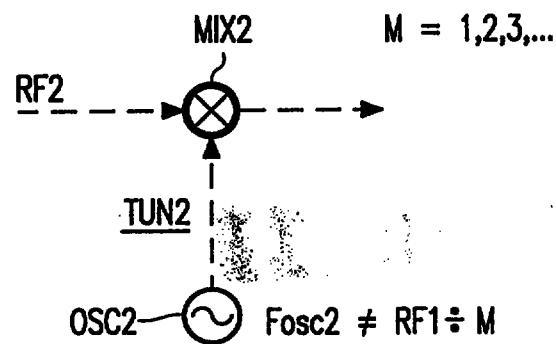
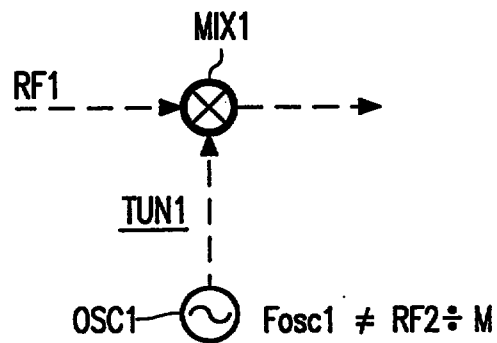


FIG. 2

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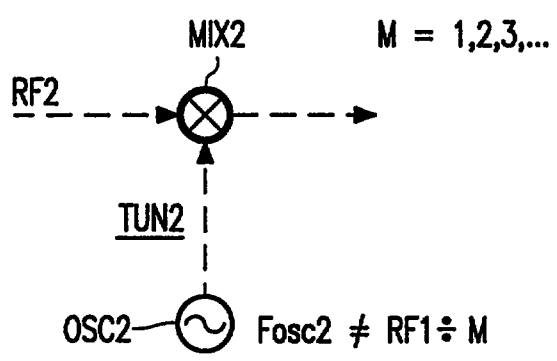
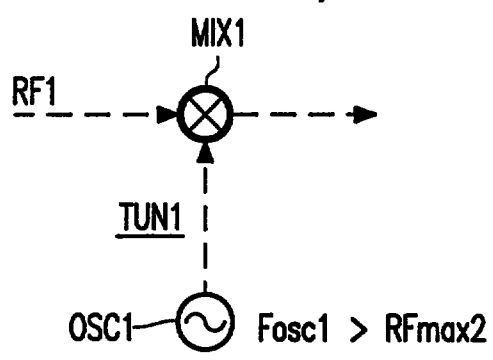


FIG. 3a

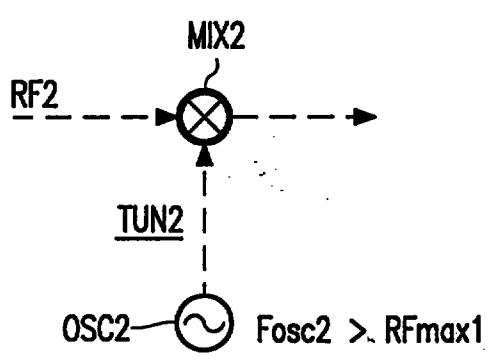
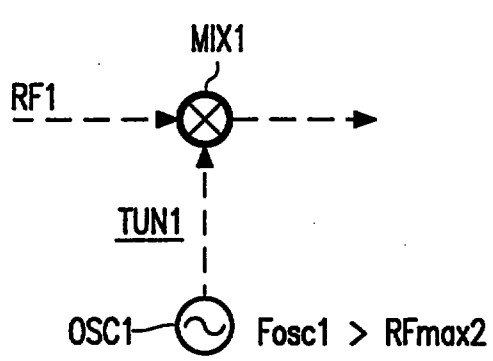


FIG. 3b

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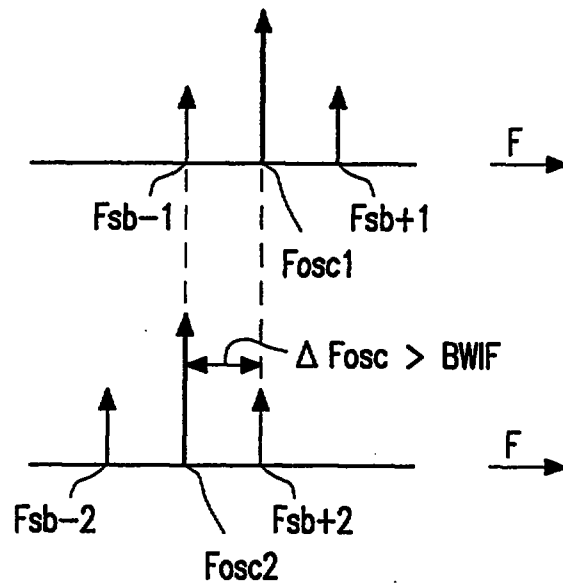


FIG. 4

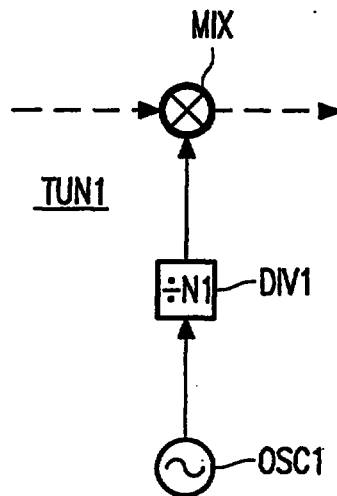


FIG. 5a

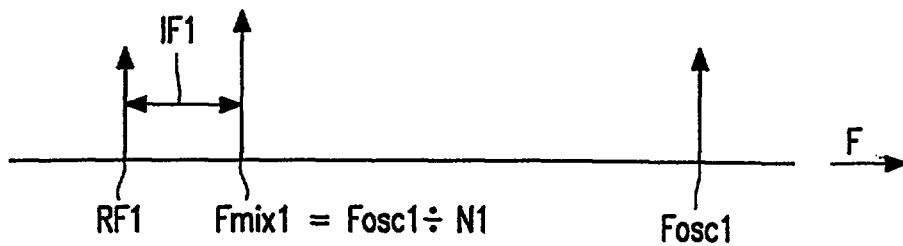


FIG. 5b

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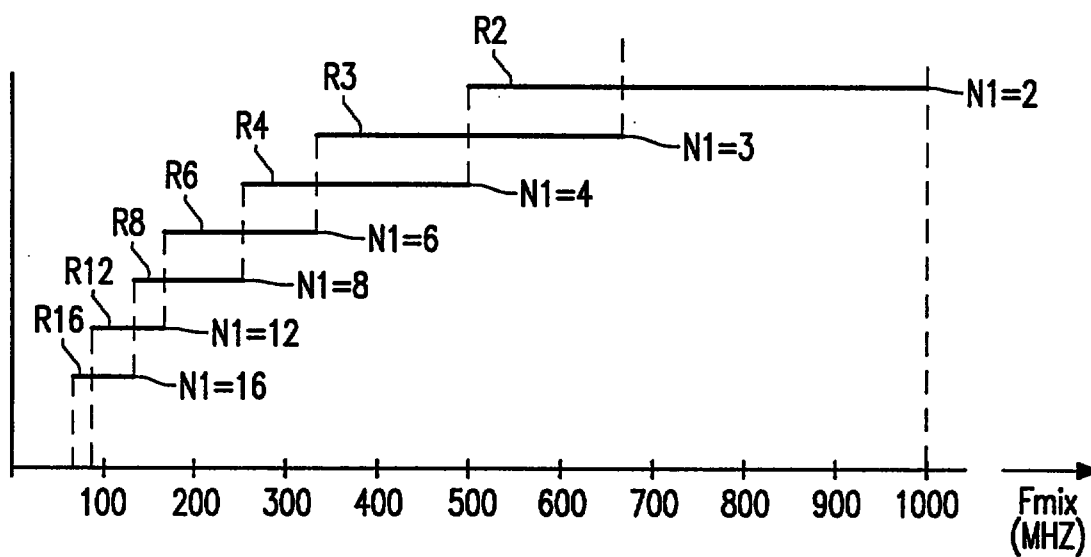


FIG. 6

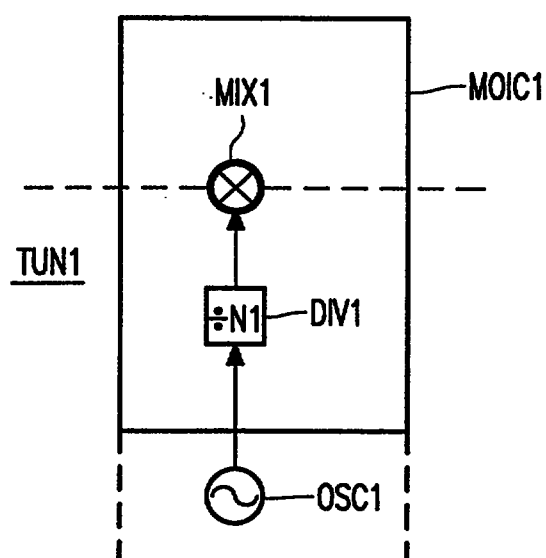


FIG. 7

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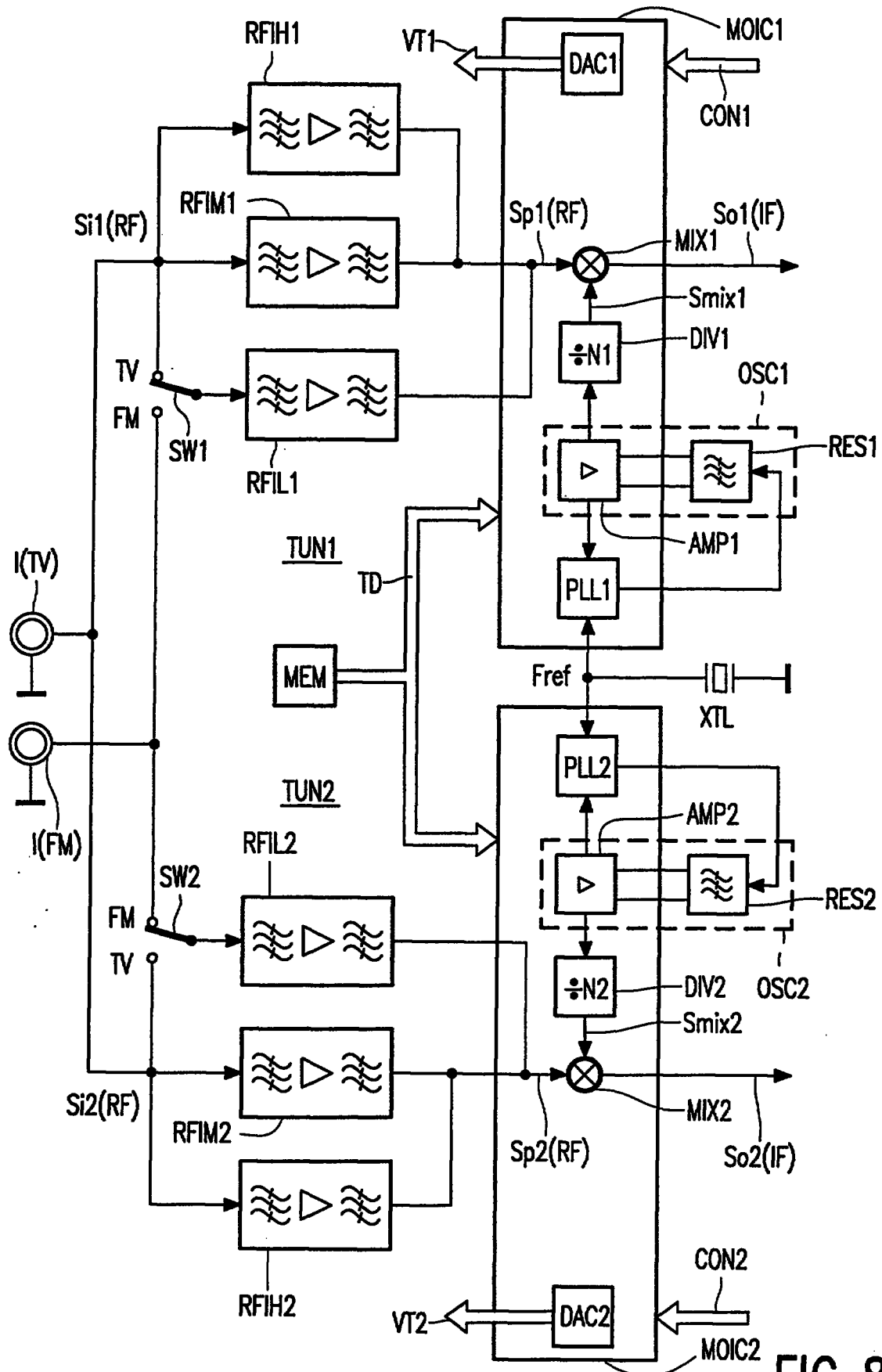


FIG. 8

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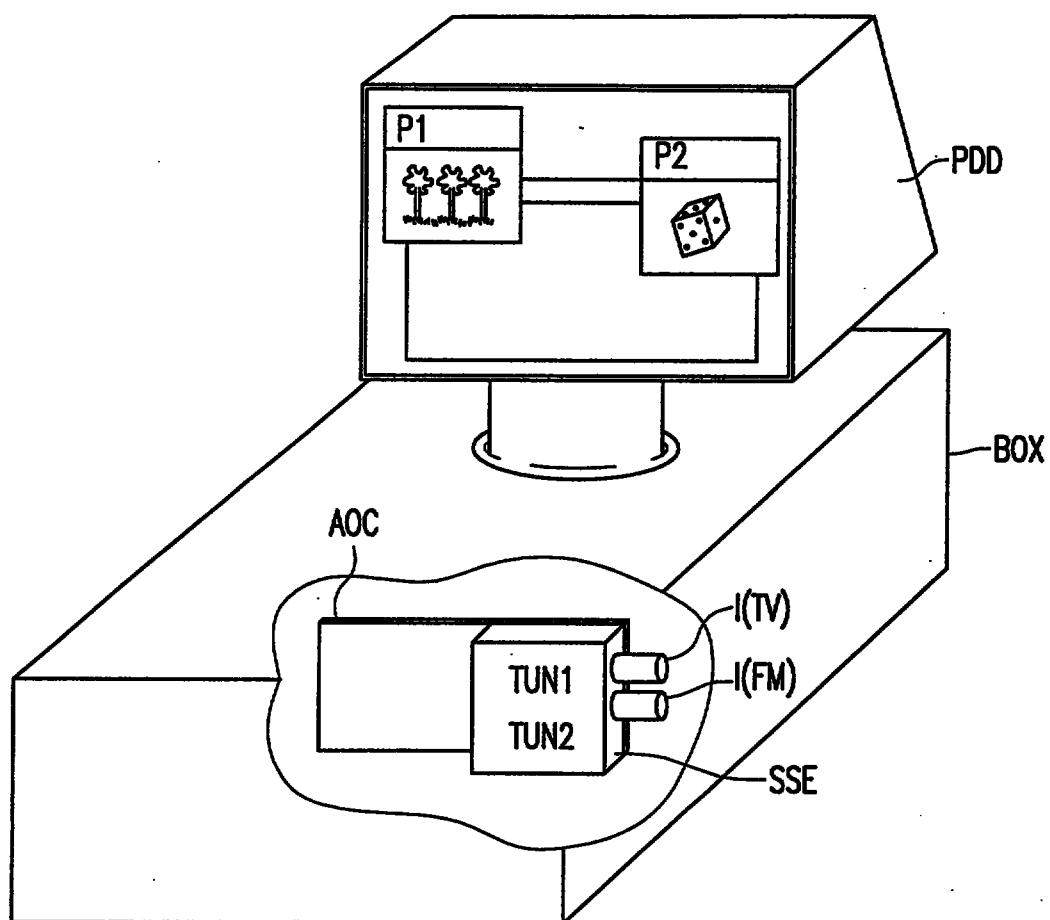


FIG. 9

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