

Multi-band radio transceiver

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The invention relates to a radio transceiver for a first and/or at least a second frequency band, having a conversion to an intermediate frequency *via* a mixing oscillator frequency.

- 5 Multi-band radio transceivers make it possible, for example, to operate as mobile radio transceivers alternately on at least two different radio systems.

US 5,020,092 has disclosed a mobile radio transceiver whose first
 10 frequency band has a range from 915 - 940 MHz and whose second frequency band has a range from 860 - 885 MHz. To set a specific radio channel in either frequency band, a reference oscillator and a frequency synthesizer generate a first mixing frequency with which the antenna input signal is mixed in a first mixer. A second oscillator and a second mixer convert the received signal from the obtained first intermediate frequency
 15 stage to a second intermediate frequency stage after it has been amplified and filtered. After passing through a bandpass filter, whose bandwidth can be changed in dependence on the selected frequency band, the received signal is finally demodulated.

In this known multi-band radio transceiver, the same first intermediate frequency stage is used for the two frequency bands. Because the frequency bands lie
 20 relatively close together (860-885 MHz, 915-940 MHz), the mixing oscillator used may be structured so that it completely includes the frequency range necessary for a downward mixing or upward mixing respectively, of the two frequency bands.

During the development of multi-band radio transceivers having radio frequency bands which are relatively wide apart, it has been found that various
 25 problems occur for the two radio frequency bands if a common mixing oscillator is used. To use the mixing oscillator as a variable-frequency oscillator in the two frequency bands, stringent requirements are to be imposed especially on the spectral purity of the oscillator when the tuning range and level constant are simultaneously



equally high, which requirements can, in principle, be solved, it is true, but are also linked with costs. In addition, to minimize the spurious responses, according to the state of the art the intermediate frequency is selected to be about 10% of the receive frequency. In the case of radio frequency bands that are very wide apart, different
5 filters are necessary, which increases the cost of components and storage means.

JP-A 05-244 032 has disclosed a radio transceiver in which the provided mixing frequency is selected to lie approximately midway between the first and second frequency bands.

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It is an object of the invention to provide a radio transceiver of the type set forth in the opening paragraph, which is extremely suitable for radio frequency bands that are relatively wide apart.

This object is achieved with a radio transceiver of the type described
15 above by the features defined in the characterizing part of Claim 1.

The difference between the mixing oscillator frequency and the receive frequency of the lower frequency band can thus be used as the intermediate frequency for the lower frequency band, and the difference between the mixing oscillator frequency and the receive frequency of the upper frequency band can be used as the
20 intermediate frequency for the upper frequency band. Advantageously, the same mixing frequencies can be used for the two frequency bands, while the frequency coverage of the mixing oscillator ideally continues to be restricted to the wider of the two mixing frequency bands.

In this manner only a single common mixing oscillator needs to be used
25 even with multi-band receivers having radio frequency bands that are relatively wide apart. Also when the concept of dual-bandwidth receiver according to the invention is implemented for only a single bandwidth (e.g. GSM on 900 MHz or DCS 1800 on about 1.8 GHz), there are technical advantages and there is a saving of costs, because, as a result, the same set of components can be used for the two frequency bands, which
30 brings about a cost reduction. Due to the high intermediate frequency, also the space needed for the filters is reduced, which is very important for handhelds which are to be extremely small-sized.

For example, if the frequency of the second frequency band is twice as

high as that of the first frequency band, this will lead to an intermediate frequency that corresponds to half the first frequency band or a quarter of the second frequency band. For radio frequency bands in the GHz range such an intermediate frequency is extraordinarily high, which calls forth special attention to the spurious responses.

5 This concept has appeared to be extremely advantageous when surface-wave filters are used as intermediate frequency filters. For these high frequencies these filters are extremely small and cost-effective and they thus support the concept of a smallest possible model. As a result of the high intermediate frequency, also the image frequency lies very remote, so that also the cost of filter circuitry in the low-frequency
10 preamplifier stage is strongly diminished.

 Due to the diminished requirement as to adjacent-channel selectivity, very small and cost-effective surface-wave filters can thus be used in the HF preselector. It has appeared that as a result of the measures according to the invention a GSM or DCS 1800 receiver can be manufactured about three times smaller than the conventional
15 superheterodyne receiver.

 The invention will be further described with reference to an embodiment represented in the drawing Figures, in which:

20 Fig. 1 shows a circuit diagram for a multi-band receiver according to the invention, and

 Fig. 2 gives a representation of the position of the frequency band of the mixing oscillator relative to a first and a second frequency band.

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 Fig. 1 shows the best embodiment for a mobile radio transceiver which makes it possible to subscribe to three different radio services operating in different frequency bands. In the embodiment the first radio service is the European mobile radio system GSM to which is assigned the frequency band which has a bandwidth from 890
30 to 960 MHz. The second mobile radio system DCS 1880, which is in the planning phase at the time of this application, is assigned the frequency band from 1710 to 1880 MHz. The third frequency band from 1880 to 1900 MHz is provided for the DECT standard (Digital European Cordless Telephone) system.





As the second and third frequency bands are lying close together, the embodiment comprises for these two frequency bands a common antenna 20, a common antenna combiner 21, a common high-frequency input stage 22 with associated preselection, and a common transmitter output stage 23. As the first frequency band lies
5 at about half the frequency of the second and third frequency bands, a separate antenna 10, a separate antenna combiner 11, a separate high-frequency input stage 12 and a separate transmitter output stage 13 are provided for the first frequency band. Furthermore, the mobile radio transceiver shown in Fig. 1 comprises a common mixer 30, a common mixing oscillator 31 and also change-over switches 32 and 33. In
10 addition, an intermediate frequency processor 40, a demodulator 41 coupled to a loudspeaker, and an intermediate frequency processor 42 and a modulator 43 coupled to a microphone are provided.

As shown in Fig. 2, the frequency band of the GSM system in the radio systems selected in the embodiment covers 70 MHz, the DCS 1800 and DECT
15 frequency bands, however, adjacent to each other, covering 190 MHz. If exactly the arithmetical mean of the intermediate frequencies of these two frequency bands were chosen as a first mixing frequency, there would be an average mixing oscillator frequency f_{LO} of 1390 Mhz. This gives an intermediate frequency f_{ZF} of 465 MHz.

The smallest attainable tuning range of the mixing oscillator depends on
20 the larger bandwidth of the two radio systems. In the embodiment this tuning range is thus 190 MHz. For the frequency bands chosen in the embodiment, the intermediate frequency can be chosen at will between 410 and 470 MHz, without this causing the 190 MHz minimum oscillator tuning range to be increased. Any different choice of intermediate frequency beyond this range calls forth a proportionally higher tuning
25 range of the mixing oscillator. In the embodiment, for example, for each frequency deviation of the intermediate frequency beyond the 410 to 470 MHz range the 190 MHz minimum tuning range of the mixing oscillator rises by twice the frequency deviation. To achieve a highest possible spectral value of the mixing oscillator, an intermediate frequency can be selected which is situated, if possible, in the minimum tuning range of
30 the mixing oscillator, or at least close to this minimum tuning range.

Due to the relatively high intermediate frequency the freedom to choose the exact intermediate frequency is considerably constrained as a result of spurious responses. Spurious responses are input frequencies which are projected exactly on the

selected intermediate frequency by harmonics of interference signals at these frequencies and harmonics of the mixing frequency. Therefore, in the embodiment the receiving input stages 12, 22 comprise surface wave filters which sufficiently attenuate spurious responses situated outside the receiving band. Spurious responses within the selected
5 receiving band can only be attenuated by the mixing operation itself. Especially suitable for this purpose is a ring mixer which realises sufficient attenuation of spurious responses within the receiving band with appropriate mixer symmetry.

Alternatively, also a highly symmetrical Gilbert cell mixer is suitable. The advantage of a Gilbert cell mixer is that it can be integrated. In this case separate
10 mixers are needed for the transmit path and the receive path.

It has appeared that intermediate frequency ranges which contain lower-order mixing products of the received input signal and of the mixing frequency, can reach comparatively high levels that would fully mask a weak wanted signal. In view of this, an intermediate frequency of 400 MHz has appeared to be the most suitable. As a
15 result, the frequency previously explained is shifted downward by only 10 MHz for the VCO mixing frequency range, which has appeared to be the best compromise between the minimum VCO tuning range and acceptable suppression of spurious responses.

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CLAIMS:

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1. Radio transceiver for a first and/or at least a second frequency band, having a conversion to an intermediate frequency *via* a mixing oscillator frequency (f_{LO}), characterized in that a common mixing oscillator (31) is provided for a transmitting and receiving section (11, 12, 13, 21, 22, 23) of the first and/or at least the
5 second frequency band and in that the intermediate frequency (f_{ZF}) is the same for the transmitting and the receiving section.
2. Radio transceiver as claimed in Claim 1, characterized in that approximately a difference between the mixing oscillator frequency (f_{LO}) and a receive frequency of the first frequency band is provided as the intermediate frequency (f_{ZF}) for
10 the first frequency band and in that approximately a difference between mixing oscillator frequency (f_{LO}) and a receive frequency of the second frequency band is provided as the intermediate frequency (f_{ZF}) for the second frequency band.
3. Radio transceiver as claimed in Claim 1 or 2, characterized in that a mixer (30) for the transmitting and receiving sections is a Gilbert cell mixer.
- 15 4. Radio transceiver as claimed in Claims 1 to 3, characterized in that the provided mixing oscillator frequency (f_{LO}) is selected to lie approximately midway between the first and second frequency bands.
5. Radio transceiver as claimed in Claims 1 to 4, characterized in that surface wave filters are provided as intermediate-frequency filters.
- 20 6. Radio transceiver as claimed in Claims 1 to 5, characterized in that a ring mixer is provided as the mixer (30).
7. Radio transceiver as claimed in Claims 1 to 6, characterized in that the intermediate frequency (f_{ZF}) lies in the range from 380 to 470 MHz.
8. Radio transceiver as claimed in Claims 1 to 7, characterized in that the
25 intermediate frequency (f_{ZF}) is 400 MHz.
9. Radio transceiver as claimed in Claims 1 to 8, characterized in that the radio transceiver is a mobile radio transceiver, more specifically, a handheld operating according to the GSM and/or DECT and/or DCS 1800 standard.



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10. Transceiver section for a radio transceiver as claimed in one of the Claims
1 to 9.

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