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(54) **RF-filtering solution for a radio transmitter/receiver**

(57) In this radio set filtering solution, all passive filtering elements in the transmission and reception branch are combined as an integrated filtering unit (25). The active radiofrequency components (11, 14, 17, 30) are connected to the ports of the filtering unit directly without separate impedance matching networks, since

the impedance of the ports is adjusted so that it is correct for the internal connections of the filtering unit. The filtering unit may contain a duplex filter (25a, 25b), in which case it is connected directly to the antenna (21). Also, by adjustment of the antenna port, a separate antenna-impedance matching network inside the filtering unit is avoided.

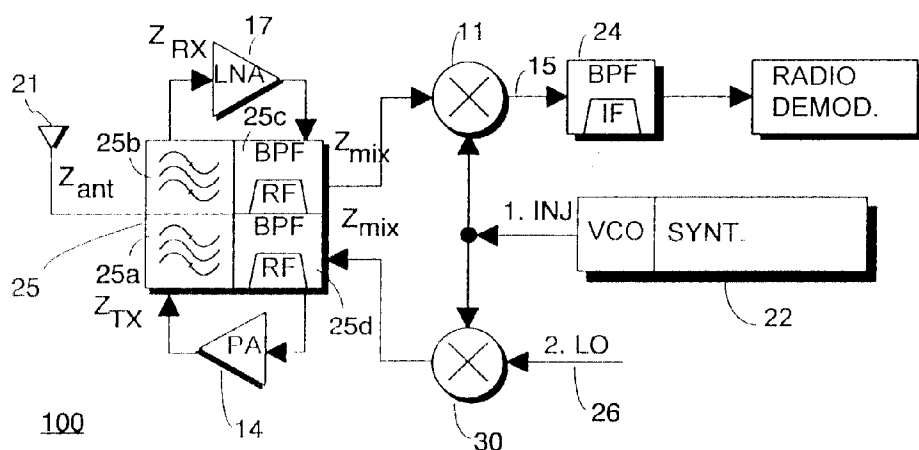


Fig. 2

Description

The invention relates in general to the design of a radio transmitter/receiver and in particular to application of filter technology to increased integration of the radio transmitter/receiver and reduction of its physical size.

The radio set according to the prior art, having bilateral action and employing time division duplex (TDD) or frequency division duplex (FDD), contains a number of RF and intermediate frequency filters on both the transmission side and the receiving side. Figure 1 shows a TDD radio 10 according to the prior art, which contains a duplex filter 33 connected to the antenna 21, for separation of the transmitted and received signals one from the other. The output port of the duplex filter is connected to a low-noise amplifier (LNA) 17 via an impedance matching network 12. The LNA amplifies the received radio signal. It is followed by a band-pass filter 18, which further filters the received signal. Also, between the LNA and the band-pass filter 18 there is an impedance-matching circuit 16. All impedance-matching circuits in the Figure have been shown as specific combinations of inductive and capacitive components, but to men skilled in the art it will be clear that the use of other types of impedance-matching network is possible. The output port of the filter 18 is connected to a mixer 11, in which the received signal is mixed with the first injection signal coming from a synthesizer 22. The intermediate frequency signal (IF) obtained as a result of mixing is conveyed to the RF circuit for demodulation and further processing.

The transmitter portion of the radio 10 comprises a second local oscillator signal (LO) 26, which is brought in by the forward stage (not illustrated) of the transmitter and is mixed in a mixer 30 with the first injection signal. The output of the mixer 30 is carried to a band-pass filter 13, which is usually situated upstream from the power amplifier 14 of the transmitter. The output of the power amplifier 14 is connected to the input of a duplex filter 15 via an impedance-matching circuit 19. A further, similar impedance-matching network 20 (*sic*) is found between the power amplifier 14 and the band-pass filter 13. Between the power amplifier 14 and the duplex filter 15 there is frequently a directional coupler (not shown), with which it is possible to measure the power level of the signal going to the antenna. The antenna port of the duplex filter 33 is connected to the antenna of the transmitter/receiver via an impedance-matching circuit 23.

The integration of two successive radiofrequency signal processing blocks or RF blocks (for example LNA 17 and mixer 11) and an "off-chip" filter 18 between them is generally difficult. The filter may for example be a helical, dielectric or other equivalent filter and its use is necessary for the functioning of the described radio structure 10. The difficulty lies chiefly in the fact that, if an "off-chip" filter and RF blocks are integrated on the same board, then compared with RF blocks created with IC technology the large size of the filter necessitates large

connection strips, the electrical stray quantities and inductive couplings caused by which impair the selectivity of the filter. The use of an "off-chip" filter between RF blocks makes full integration of the structure uneconomical in practice. And thus portable radio sets according to the prior art, such as mobile telephones, are composed of a number of RF blocks formed by lumped, discrete components, between which filters are connected.

The standard impedance at the junctions between the discrete components and the filters has been established as 50 Ω . Filter and semiconductor manufacturers adjust the input and output impedances of their products to a standard value in order to facilitate modular design. The input and output impedances of RF circuits would often benefit from being smaller or greater, for example the input impedance of the LNA 17 could, as it is, be approximately 100 Ω . Adjustment to the standard value has to be done by a matching circuit, which is built from independent components or which the semiconductor manufacturer integrates into an RF circuit. The matching circuits required for the standard impedance take up space, increase interference and attenuation and raise manufacturing costs. In order for the size of the radio set and its manufacturing costs to be substantially reduced from current values, it is necessary to develop a transceiver filtering solution which permits easier integration of the said blocks.

Impedance matching may also be viewed from the standpoint of the antenna and the associated antenna filtering solution. In data transmission networks use is generally made of time division multiple access (TDMA), in which transmission and reception occur in different time intervals. If the transmission and reception frequency are the same, the mobile telephone comprises an antenna switch used for separation of the signals, which connects the antenna in turn to the transmission or reception branch of the set. If transmission and reception occur in different frequency bands, a filter similar to the duplex filter used in analog telephones may be employed as a separating unit. The latter alternative is also involved in systems applying frequency division multiple access (FDMA).

In a digital mobile telephone employing frequency division duplex (FDD), filters are also required in addition to the RF circuit described, since there must be selectivity at the receiver input and it must protect the low-noise pre-amplifier. At the transmitter output the harmonic multiples of the transmission frequency and other spurious emissions such as image frequencies must be attenuated. In addition, the filters remove noise generated by the transmitter chain to the receiver band. Also, the lower frequencies of the transmission band must be attenuated by a separate filter. In a system employing time duplex, such as the DECT (Digital European Cordless Telephone) system, in addition to the above different arrangements must be employed to ensure that, during signal transmission, spurious emissions towards the antenna generated in the receiver are adequately atten-

uated.

Regardless of whether the radio set employs an antenna coupling or simply frequency selective filtering for separation of the transmitted and received signal, the impedance of the antenna must be matched to the connected coupler or filter block. The standard 50 junction impedance again necessitates at least one impedance-matching circuit, which in Figure 1 is marked by reference number 23.

The same observations concerning loss, interference and costs apply to this circuit as were presented above in relation to circuits 12, 16, 19 and 20.

An aim of this present invention is to provide a filtering solution for a transmitter/receiver, which increases the degree of integration of the set while removing and/or reducing the drawbacks of the prior art as described above. Another aim of the invention is to present a radio set of small design which is reasonable in terms of its manufacturing costs and which with regard to its operating frequencies and other specifications is readily applicable to differing systems.

The aims of this invention are endeavoured to be attained by combining the radiofrequency filters of the transmission and reception chains into a single structure, in which there are ports for the connection of other components. The impedances of the ports are so chosen, by dimensioning of the components of the filtering unit, that other components may be attached to them without separate matching networks.

The characteristic feature of the filtering solution according to this invention is that it comprises, in an integrated filtering unit,

- a first filter for filtering of the signal before it is conducted outside the filtering unit to a certain first active radiofrequency component and
- a second filter for filtering of the signal after it is conducted through said first active radiofrequency component.

The invention is also concerned with a radio set in which use is made of a filtering solution of the type described above. The characteristic feature of a radio set according to the invention is that it comprises an integrated filtering unit and means for conducting the filtered signal from said integrated filtering unit to a certain first active radiofrequency component and means for conducting the signal from said first active radiofrequency component back to said integrated filtering unit for further filtering.

The invention is founded on the belief that the opportunities offered by filter technology should be used as a basis for design of the radio structure. A modern radiofrequency filter is formed from transmission line resonators, possible discrete components, transmission lines connecting these and a frame structure, which is most commonly a low-interference substrate, a dielectric (most commonly ceramic) frame block or a com-

bination of these. The filter entity is surrounded by an electrically conductive casing. In accordance with the invention, the filters of the transmission and reception branches are integrated into a single filtering unit, in which all parts are assembled on the same low-interference substrate and are situated inside a common cover which protects them from interference. This unit forms one component of a mobile telephone or on the circuit board of another radio set.

The active components may be realized as discrete components, as a single GaAs circuit or as a multichip module, which is known as such and is found in the prior art. The integrated filtering unit in the present invention comprises the necessary ports for connection to it of the active components and the antenna. The transmission lines and other circuit elements contained in the filtering unit are so dimensioned that the impedance of each port corresponds to the impedance level which is natural to the components which are to be connected to it. Thus all matching circuits in which the junctions of the discrete components are adjusted to the 50 standard value become unnecessary. Individual filtering modules are dispensed with and the reliability of the entire structure is enhanced, its total weight falls and its physical size decreases. In addition, economies are made in the manufacturing process. What is important with regard to the electrical functioning is the elimination of parasitic elements, which results in an acceleration of electrical functioning and a decrease in overall power losses.

The invention will now be described in greater detail with reference to a favourable embodiment presented by way of example and to the attached drawings, where

- Figure 1 represents a particular radio set in accordance with the prior art,
- Figure 2 represents a radio set in accordance with the invention, and
- Figure 3 shows in outline the design of an integrated filtering unit in accordance with the invention.

In the above description of the prior art reference is made to Figure 1, and so in the following account of the invention and of favourable embodiments thereof reference will chiefly be made to Figures 2 and 3. In the drawings, the same reference numbers are employed for parts which correspond to each other.

Figure 2 shows a block diagram of a radio set in which the filtering solution conforms to a favourable embodiment of the invention. The central part of the transmission and reception chains of the radio set is an integrated filtering unit 25, which contains a duplex filter, made up of two filter branches 25a and 25b, and two band-pass filters 25c and 25d. In the reception branch 25b of the duplex filter and in the first band-pass filter 25c there are ports for connection of a low-noise amplifier 17 in such a way that the input thereof is connected to the duplex filter and the output thereof is connected

to the band-pass filter. Correspondingly, in the second band-pass filter 25d and in the transmitter branch 25a of the duplex filter there are ports for connection of a power amplifier 14 in such a way that its input is connected to the band-pass filter and its output is connected to the duplex filter. In addition, in the first band-pass filter 25c there is a port for conducting the signal to a mixer 11 and in the second band-pass filter 25d there is a port for conducting the signal from mixer 30. In the duplex filter there is a port for connection of the antenna 21.

The above-mentioned ports in the filtering unit 25 each have a certain impedance level. The impedance level of the ports connected to the low-noise amplifier 17 is in Figure 2 designated Z_{RX} and the impedance level of the ports connected to the power amplifier 14 is designated Z_{TX} . The impedance level of the input port and the output port of a certain amplifier is not necessarily the same, in which case the levels in the filtering unit also have to be adjusted differently, but for clarity only one designation is used for each amplifier. The impedance level of the ports connected to the mixers 11 and 30 is designated Z_{mix} and the impedance level of the port connected to the antenna 21 is designated Z_{ant} .

The combination of filters 25a - 25d in a single integrated filtering unit means in practice that all parts connected to these filters are realized using the same framework and conductive protective casing. It is assumed, for example, that the filters chosen will be filters based on dielectric resonators. In that case a possible structure would be as shown in Figure 3. The framework is made up of a low-interference substrate 40 and a ceramic frame block 41 connected to each other, in the latter of which resonator apertures 42 are formed in a way which is in itself familiar. In that surface of the ceramic frame block which faces the substrate 40 and which cannot therefore be seen in the drawing, it is possible to form conductive patterns for connection to the resonator apertures 42. On the surface of the substrate are formed transmission lines 43 and circuit lands 44; the former of these provide the internal connections of the structure, while the components attached to the latter affect the electrical characteristics of the structure. The ports by means of which the integrated filtering unit 25 is connected to the antenna, to the amplifiers and to the mixers take the form of conductor strips 45 extending to the edge of the substrate. The structure includes a protective cover 46 made from a thin metal plate or other electrically conductive material.

In one version of the structure shown in Figure 3, not all resonators are contained in the same ceramic frame block, but the filter contains a number of discrete blocks. As a result of these discrete blocks, the resonators may easily be of differing lengths, which in a single-block filter would necessitate a dielectric block which was stepped in respect of the other end face. In addition, resonator groups between which no electromagnetic connection is to occur may be easily insulated one from another by arranging between them the metallized sur-

face of two blocks. On the other hand, as the number of blocks increases, so too does the number of stages in the filter manufacturing process.

The invention is not restricted to the internal structure of the integrated filtering unit. As resonators use may be made not only of dielectric resonators but also of helical, stripline or coaxial resonators, for example. The best framework for a structure based on helical resonators is a circuit board on one edge of which are digitate projections to which the cylindrical coil conductors of the helical resonators are attached. The same circuit board acts also as the substrate for transmission lines and discrete components. The electrically conductive protective casing is divided into a number of compartments for the helical resonators, the resonators being separated by partitions in which there may be window couplers. The fundamental structure of the filter based on helical resonators is as such well known in the field.

In some cases the modular structure may necessitate one of the filters contained in the integrated filtering unit 25 in Figure 2, for example the band-pass filter 25d, being a discrete component. The concept according to the invention may be adapted in such a way that only some of the filters form part of the same integrated structure. In that case, however, one would lose some of the advantages introduced by the invention, since the same technical drawbacks would apply in relation to the discrete filter as have been dealt with in the description of the prior art above.

Mobile telephones are currently the most important area of application of portable radio technology. Since there are many different mobile telephone systems in operation throughout the world, it must be assumed that so-called dual-mode telephones, that is, telephones which operate in different systems at the user's discretion according to circumstances, will become generalized. Alternative systems may use very different frequencies. For example, dual-mode telephones for the GSM- and DECT systems have to incorporate both 900 MHz and 1900 MHz radiofrequency components. In the dual-mode application according to the present invention all the transmission- and reception-frequency passive filter components of the different systems, or at least a significant proportion of them, have been combined in an integrated filtering unit, thus avoiding as many as ten separate impedance-matching networks and many separate filter components. Active components operating at radiofrequencies in different systems may further be realized as a single GaAs circuit or as a multichip module, which is connected to an integrated filtering unit via signal ports of matching impedance, in which case the structure becomes particularly small and compact in character.

Claims

1. A filter structure (25) for the filtering of radiofrequencies

cy signals in a radio transmitter/receiver, which comprises a first active radiofrequency component (17), characterized in that the filter structure comprises, in an integrated filtering unit,

- a first filter (25b) for filtering of a signal before it is conducted outside the filtering unit to the first active radiofrequency component and
- a second filter (25c) for filtering of said signal after it is conducted through the first active radiofrequency component.

2. A filter structure in accordance with Claim 1, characterized in that it also comprises, in said integrated filtering unit, impedance-matching means for the purpose of adjusting the impedances of the filtering unit ports connected to the first active radiofrequency component so that they correspond to the impedance of the corresponding ports of the first active radiofrequency component.

3. A filter structure in accordance with Claim 1, characterized in that it also comprises, in said integrated filtering unit,

- a third filter (25d) for filtering of a signal before it is conducted outside the filtering unit to a certain second active radiofrequency component and
- a fourth filter (25a) for filtering of said signal after it is conducted through said second active radiofrequency component.

4. A filter structure in accordance with Claim 3, characterized in that it also comprises, in said integrated filtering unit, impedance-matching means for the purpose of adjusting the impedances of the filtering unit ports connected to said second active radiofrequency component so that they correspond to the impedance of the corresponding ports of said second active radiofrequency component.

5. A filter structure in accordance with Claim 3, characterized in that said first (25b) and fourth (25a) filters together form a duplex filter and that said filter structure comprises an antenna port for transmission of signals between the said duplex filter and the antenna (21) attached to the said antenna port.

6. A filter structure in accordance with Claim 1, characterized in that it also comprises, in said integrated filtering unit, impedance-matching means for the purpose of adjusting the impedance of said antenna port so that it corresponds to the impedance of the antenna connected thereto.

7. A filter structure in accordance with Claim 1, characterized in that it comprises a low-interference substrate (40) for making connections (43, 44, 45), a dielectric frame block (41) connected to said substrate for the formation of dielectric resonators (42) and an electrically conductive protective cover (46) for covering said substrate and frame block.

8. A radio transmitter/receiver, which comprises a first active radiofrequency component (17), characterized in that it comprises an integrated filtering unit (25) and means for conducting a filtered signal from said filtering unit to the first active radiofrequency component and means for conducting said signal from the first active radiofrequency component back to said integrated filtering unit for further filtering.

9. A radio transmitter/receiver in accordance with Claim 8, characterized in that the first active radiofrequency component (17) is a low-noise preamplifier in the reception chain.

10. A radio transmitter/receiver in accordance with Claim 8, characterized in that it also comprises a second active radiofrequency component (14) and means for conducting a filtered signal from said filtering unit to said second active radiofrequency component and means for conducting said signal from said second active radiofrequency component back to said integrated filtering unit for further filtering.

11. A radio transmitter/receiver in accordance with Claim 10, characterized in that the said second active radiofrequency component (14) is a power amplifier in the transmission chain.

12. A radio transmitter/receiver in accordance with Claim 7, characterized in that it comprises an antenna (21) connected to said integrated filtering unit, in which case said integrated filtering unit comprises means (21a, 21b) for separation of the transmission and reception signals one from the other.

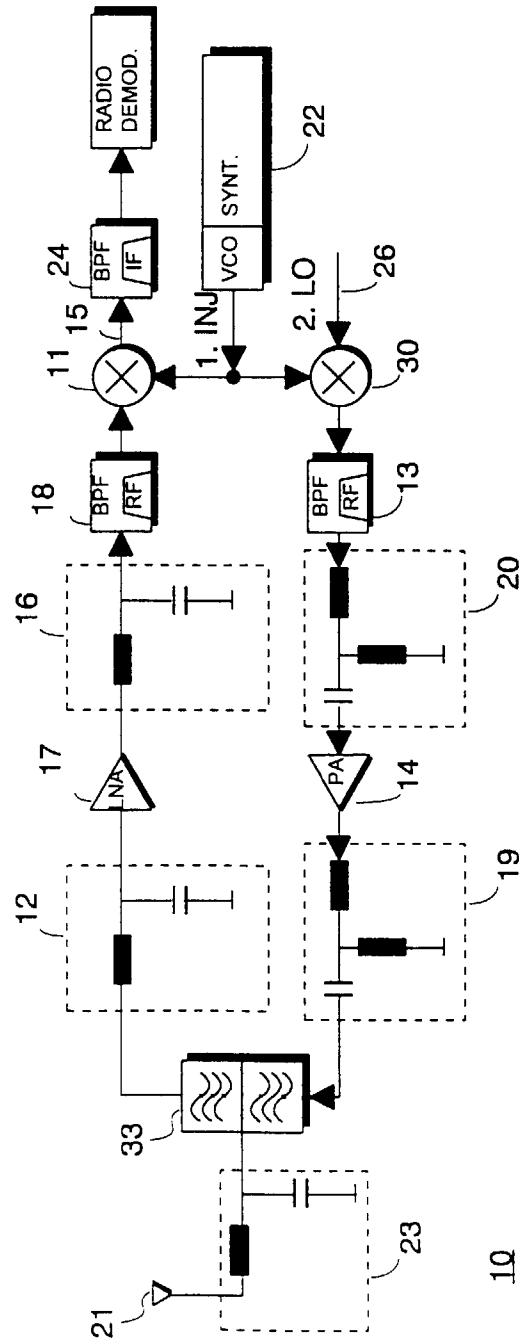


Fig. 1
PRIOR ART

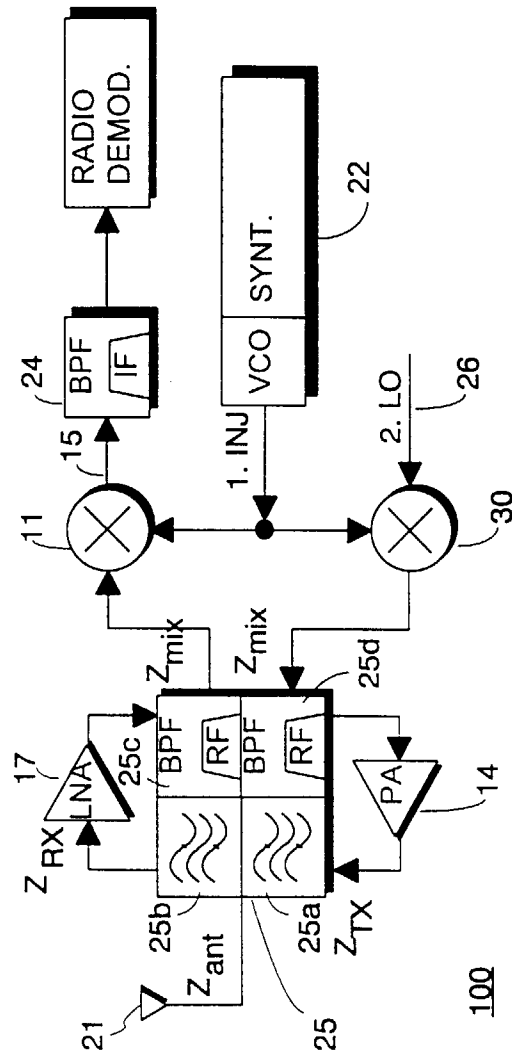


Fig. 2

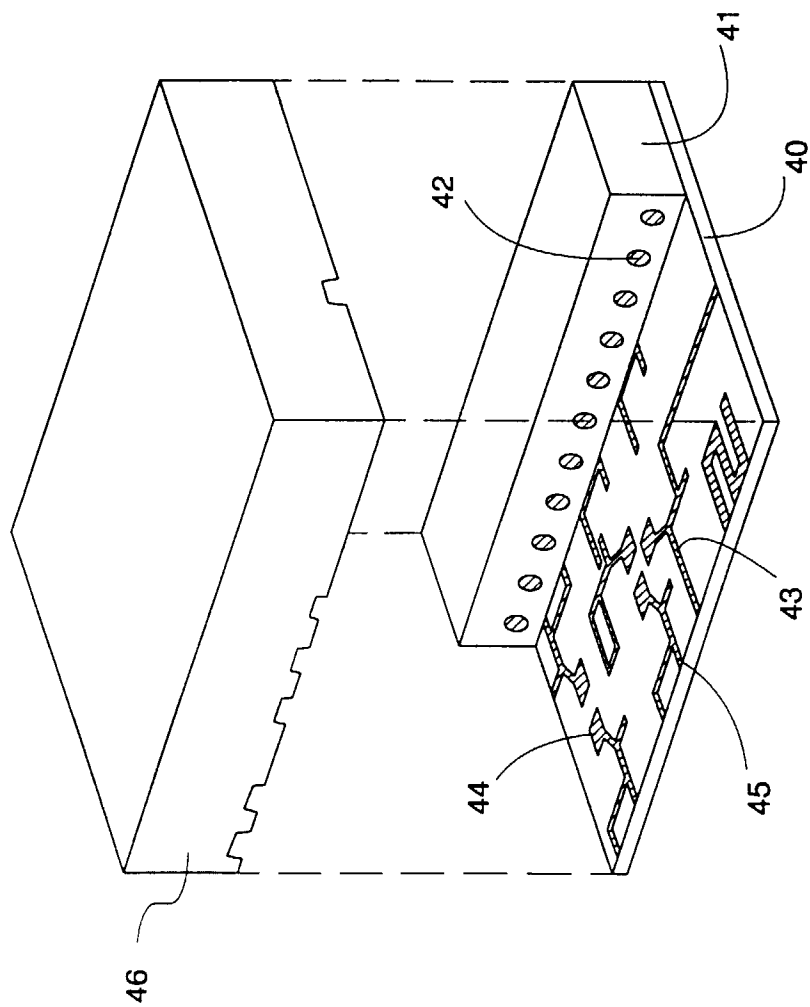


Fig. 3