(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 840 647 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.02.2015 Bulletin 2015/09

(21) Application number: **13290199.2**

(22) Date of filing: **22.08.2013**

(51) Int Cl.:
H01Q 1/02 *(2006.01)* ***H01Q 1/24*** *(2006.01)*
H01Q 21/00 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **ALCATEL LUCENT**
92100 Boulogne-Billancourt (FR)

(72) Inventors:
- **Pascht, Andreas**
70435 Stuttgart (DE)
- **Wiegner, Dirk**
70435 Stuttgart (DE)

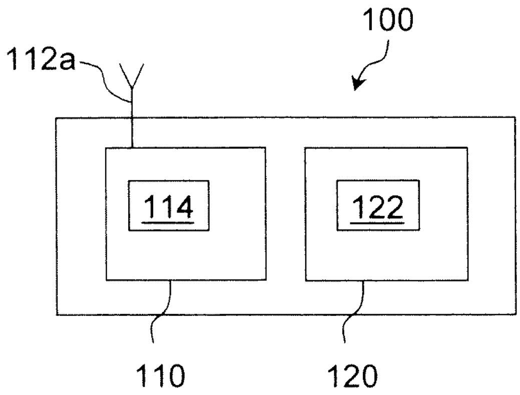
(74) Representative: **DREISS Patentanwälte PartG mbB**
Patentanwälte
Postfach 10 37 62
70032 Stuttgart (DE)

Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) Antenna module

(57) The invention relates to an antenna module (100) for a communications system, wherein said antenna module (100) comprises a primary submodule (110), wherein said primary submodule (110) comprises one or more antennas (112a, 112b) and at least one amplifier unit (114) coupled with one of said antennas (112a, 112b), and wherein said antenna module (100) comprises a secondary submodule (120), wherein said secondary submodule (120) comprises at least one signal processing device (122), wherein said secondary submodule (120) is located outside of said primary submodule (110).

Fig. 1a



EP 2 840 647 A1

Description

Field of the invention

[0001] The present invention relates to an antenna module for a communications system, for example of a cellular communications network, wherein radio frequency signals are used for communications.

Background

[0002] Prior art antenna modules are disadvantageous in that a high number of integrated electronic components is arranged in said antenna modules contributing to an increased amount of heat energy the removal of which requires substantial constructional efforts.

Summary

[0003] In view of this, it is an object of the present invention to provide an improved antenna module which avoids the disadvantages of the prior art. According to the present invention, this object is achieved in that said antenna module comprises a primary submodule, wherein said primary submodule comprises one or more antennas and at least one amplifier unit coupled with one of said antennas, and wherein said antenna module comprises a secondary submodule, wherein said secondary submodule comprises at least one signal processing device, wherein said secondary submodule is located outside of said primary submodule.

[0004] The partitioning of the antenna modules into different submodules according to the embodiments advantageously provides further degrees of freedom regarding the arrangement and distribution of electronic components within these submodules and also facilitates removal of dissipated heat therefrom.

[0005] Particularly, since the signal processing device is arranged in the secondary submodule according to the embodiments, the primary submodule which comprises the amplifier unit is not burdened with the heat dissipated by the signal processing device. Also, each submodule may be cooled separately by active or passive cooling means, whereby a basically thermally independent operation of both submodules is guaranteed and the reliability of the antenna module is increased.

[0006] According to an embodiment, said primary submodule comprises a housing, wherein said secondary submodule is arranged outside said housing of the primary submodule which advantageously ensures that heat dissipated within said secondary submodule does not affect the primary submodule.

[0007] According to a further preferred embodiment, said secondary submodule may be arranged at an outer surface of the housing of the primary submodule. According to a further embodiment, said secondary submodule may comprise a housing.

[0008] According to a further embodiment, primary cooling means are provided which are thermally coupled with said primary submodule or at least one component thereof. The primary cooling means may e.g. comprise passive cooling means, such as cooling fins or the like or active cooling means, such as e.g. forced air cooling systems or Peltier elements or the like.

[0009] According to a further embodiment, secondary cooling means are provided which are thermally coupled with said secondary submodule or at least one component thereof, wherein said secondary cooling means are not thermally coupled with said primary submodule or its primary cooling means. Thereby, a thermal decoupling of the respective cooling systems or cooling means, respectively, is ensured.

[0010] According to a further embodiment said primary submodule comprises a transmit path comprising a transmit amplifier and an associated transmit filter, a receive path comprising a receive amplifier and an associated receive filter, wherein said primary submodule optionally also comprises a feedback path, said feedback path comprising a feedback amplifier and an associated feedback filter.

[0011] According to a further embodiment, said secondary submodule comprises a first signal processing path for upconverting a transmit signal from a first frequency range to a second frequency range, and at least one further signal processing path for downconverting a receive signal and/or a feedback signal from a third frequency range to a fourth frequency range. According to one example embodiment, the first frequency range may correspond to a baseband frequency range or an intermediate frequency range, wherein the second frequency range may correspond to an RF (radio frequency) frequency range such as e.g. about 400 MHz to about 10 GHz.

[0012] According to a further embodiment, said secondary submodule comprises at least one digital to analog converter and/or at least one analog to digital converter.

[0013] According to a further embodiment, said secondary submodule comprises at least one digital interface for exchanging digital signals with at least one external device.

[0014] According to a further embodiment, said secondary submodule comprises at least one analog interface for exchanging analog signals with at least one external device, preferably with said primary submodule. This way, e.g. the power amplifier of the primary submodule may be supplied with an analog RF signal to be transmitted via one of the antenna module's antennas, wherein said analog RF signal may be obtained by upconversion of a respective baseband or IF (intermediate frequency) signal within said secondary submodule.

[0015] A further solution to the object of the present invention is given by an antenna system according to claim 11. The antenna system comprises a plurality of antenna modules according to the embodiments, wherein at least two antenna modules are configured to process radio frequency signals of same or different frequency ranges.

[0016] According to a preferred embodiment, a first number of antenna modules is provided which are configured to process radio frequency signals of the first frequency range, and a second number of antenna modules is provided which are configured to process radio frequency signals of a second frequency range, wherein said second frequency range is different from said first frequency range.

Brief description of the figures

[0017] Further features, aspects and advantages of the present invention are given in the following detailed description with reference to the drawings in which:

Figure 1a	schematically depicts an antenna module according to a first embodiment,
Figure 1b	schematically depicts a perspective view of an antenna module according to a further embodiment,
Figure 2a	schematically depicts a primary submodule according to an embodiment,
Figure 2b	schematically depicts a primary submodule according to a further embodiment,
Figure 3	schematically depicts a secondary submodule according to an embodiment,
Figure 4	schematically depicts an antenna system according to an embodiment, and
Figure 5	schematically depicts an antenna module according to a further embodiment.

Description of the embodiments

[0018] Figure 1a schematically depicts a block diagram of an antenna module 100 according to an embodiment. The antenna module 100 comprises a primary submodule 110 and a secondary submodule 120. The primary submodule 110 comprises an antenna 112a and an amplifier unit 114 which may be coupled with said antenna 112a to provide an amplified signal output by the amplifier unit 114 to the antenna 112a for transmission.

[0019] A secondary submodule 120 comprises at least one signal processing device 122 which may e.g. comprise components suitable for digital and/or analog signal processing of signals comprised in a baseband frequency range and/or an intermediate frequency (IF) range and/or in a radio frequency (RF) range. Particularly, the signal processing device 122 may also comprise digital to analog converters and/or analog to digital converters and/or upconversion means and/or downconversion means which are configured to transfer signals from a source frequency range to a target frequency range in a per se known manner, e.g. by mixing the respective signal with a carrier signal.

[0020] Advantageously, as the secondary submodule 120 is located outside of said primary submodule 110, heat dissipated by the secondary submodule 120 or its components does not affect the primary submodule 110 or its components, respectively. Thus, a thermal separation of the submodules 110, 120 and their components, respectively, is given.

[0021] In contrast to conventional antenna modules, where both the signal processing devices 122 and power amplifiers 114 are comprised within a single module, the approach according to the embodiments advantageously yields a reduced thermal load for the respective submodules 110, 120 thus contributing to a more reliable operation and an extended operating temperature range.

[0022] Figure 1b schematically depicts a perspective view of an antenna module according to a further embodiment. The primary module 110 comprises a housing 110' on a front surface of which two antennas 112a, 112b are provided in the form of basically rectangular shaped stripes. These antennas 112a, 112b may e.g. be implemented in the form of planar antennas.

[0023] A secondary submodule 120, which also comprises a housing 120', is arranged besides the primary module 110, whereby an efficient individual cooling of both submodules 110, 120 can be attained without a substantial exchange of the thermal energy between the components 110, 120.

[0024] One or more signal links may be provided between the submodules 110, 120, e.g. to provide an exchange of signals between the signal processing device 122 of the secondary submodule 120 and the amplifier unit 114 of the primary submodule 110.

[0025] According to an embodiment, the secondary submodule 120 or its housing 120', respectively, may be attached to the primary submodule 110 or its housing 110', respectively. In this configuration, the secondary submodule 120 can also be considered as a "backplane" element connected to the primary submodule 110.

[0026] Figure 2a schematically depicts a block diagram of a primary submodule 110a according to an embodiment. The primary submodule 110a comprises a power amplifier 114a and a first filter 116a. The power amplifier 114a receives at its input a signal to be amplified and provides at its output a correspondingly amplified signal, which is filtered by the filtering means 116a. The input signal to the primary submodule 110a may be provided at a first terminal 111a, and an amplified and filtered output signal is obtained at an output terminal 111b of the primary submodule 110a. The input signal provided to first terminal 111a may e.g. be an analog RF signal which has been obtained by the signal processing device 122 (Fig. 1a) of the secondary submodule 120, and which is amplified and filtered by said primary submodule (components 114a, 116a) prior to transmission over the antenna 112a (Fig. 1a).

[0027] Figure 2b schematically depicts a block diagram of a primary submodule 110b according to a further embodiment. The primary submodule 110b comprises a transmit path which comprises the components 114a, 116a already explained above with reference to figure 2a.

[0028] In addition to this transmit path 114a, 116a, a receive path is provided which comprises a receive filter 116c and a receive amplifier 114c. Optionally, also a feedback path comprising a feedback filter 116b and a feedback amplifier 114b.

[0029] As can be seen from figure 2b, the transmit path is provided with terminals 111a, 111b, as explained above with reference to figure 2a. The feedback path is connected to the output terminal 111b of the transmit path thus providing a feedback signal to an input of the feedback filter 116b. An output signal of the feedback filter 116b is forwarded to the feedback amplifier 114b, whereby an amplified feedback signal is obtained at an output terminal 111c of the feedback amplifier 114b. The amplified feedback signal obtained at said output terminal 111c may be used in a per se known manner by signal processing means, e.g. device 122 (Fig. 1a) to modify an operation of the transmit path 114a, 116a or preceding signal processing stages which provide the transmit amplifier 114a with an input signal, e.g. to account for non-linear effects of the processing chain or the like.

[0030] The receive path comprises a receive filter 116c which is configured for filtering a signal received at the terminal 111d, e.g. from an antenna 112a, 112b (Fig 1b). The filtered receive signal obtained at an output of the receive filter 116c is provided to an input of the receive amplifier 114c which at its output correspondingly provides an amplified received signal. The amplified received signal is provided at the terminal 111e of the primary submodule 110b and may e.g. be fed to a receive section of the signal processing device 122 (Fig. 1a).

[0031] According to a preferred embodiment, any combination of power amplifier (PA) and/or low noise amplifier (LNA) may be used for the components 114a, 114b, 114c.

[0032] Figure 3 schematically depicts a block diagram of a secondary submodule 120a according to an embodiment.

[0033] A first signal processing path of the secondary submodule 120a comprises a digital to analog converter 122a which converts a digital input signal received at the input terminal 121a into an analog signal. After that, the upconverter 124a performs a frequency transformation of the analog signal obtained at the output of the digital to analog converter 122a to a desired radio frequency range. Thus, at the output terminal 121b of the secondary submodule 120b, a radio frequency signal in a desired radio frequency range is obtained.

[0034] This radio frequency signal may e.g. be forwarded to the input terminal 111a of power amplifier 114a according to figure 2b, which may e.g. be effected by providing an electrically conductive connection between the terminals 121b, 111a. According to an embodiment, such connection may be a single ended connection. According to a further embodiment, also a differential-ended conductor arrangement or any other suitable signal connection may be used.

[0035] The secondary submodule 120a also comprises a second signal processing path comprising downconversion means 124b and analog to digital converter means 122b. The second signal processing path is e.g. provided for downconverting the feedback signal obtained at terminal 111c of figure 2b and for providing a corresponding digital feedback signal at terminal 121c of secondary submodule 120a. For this purpose, the terminals 111c, 121d are to be connected with each other (not shown).

[0036] A third signal processing path comprising downconversion means 124c and analog to digital converter means 122c is also provided in the secondary submodule 120a according to figure 3. The components 122c, 124c basically operate in the same manner as already explained for the components 122b, 124b. The third signal processing path receives at its input terminal 121f a filtered and amplified receive signal as provided by terminal 111e of figure 2b. At the output terminal 121e, correspondingly, a downconverted digital version of the receive signal is provided. According to an embodiment, the terminals 121a, 121c, 121e may be connected to a baseband processing unit (not shown) which performs digital baseband signal processing in a per se known manner.

[0037] If no feedback mechanism is employed, according to a further embodiment, the submodule 120a may also be implemented without the components 122b, 124b. Advantageously, according to the embodiments, the various active electronic components 114a, 114b, 114c, 122a, 122b, 122c, 124a, 124b, 124c are distributed over the primary and secondary submodules 110, 120 so that a corresponding thermal load is distributed over these submodules.

[0038] Thus, advantageously, additional degrees of freedom regarding the cooling of the submodules 110, 120 are provided. For example, also, a nominal output power of e.g. the amplifier 114a may be increased as compared to conventional antenna modules where both signal processing devices 122 and amplifiers 114 are integrated within a same module housing.

[0039] Figure 4 depicts an antenna system 1000 according to an embodiment. The antenna system 1000 comprises a plurality of antenna modules 100a of a first type, which is configured for processing signals in a first radio frequency range, for example ranging from about 800 MHz to about 1100 MHz. Also, a further antenna module 100b is provided, which is configured to process signals in a second radio frequency range, which is different from the first radio frequency range, said second RF range for example ranging from about 1900 MHz to about 2100 MHz. Thus, the antenna module 1000 according to figure 4 can advantageously handle two different radio frequency ranges. A respective transmit power may e.g. be scaled by adjusting the overall number of modules 100a, 100b.

[0040] Also depicted by figure 4 is a signal processing stage 1010 which is configured to receive signals from a digital baseband processing unit (not shown) and to provide the respective signals to the different antenna modules 100a, 100b of the antenna system 1000.

[0041] Advantageously, different antenna modules 100a, 100b may be combined with the antenna system 1000, whereby the antenna system 1000 can easily be adapted to further target radio frequency ranges. For example, if the antenna system 1000 is also required to cover a third radio frequency range, one or more further antenna modules (not shown) may be added to the antenna system 1000, wherein these additional antenna modules may be configured to handle the desired third radio frequency range.

[0042] Figure 5 depicts a further embodiment of an antenna module 100. The antenna module 100 comprises cooling means 130, which are presently configured as passive cooling means comprising a plurality of cooling fins. Alternatively or additionally, active cooling means such as a Peltier cooling device or forced air cooling or the like may also be provided.

[0043] According to a further preferred embodiment, the primary submodule only comprises one or more amplifier units 114 (Fig. 1a) and optionally associated filters 116a (Fig. 2a). Preferably, according to an embodiment, the primary submodule 110 does not comprise signal processing devices such as A/D or D/A converters 122a, 122b, 122c or upconversion/downconversion units 124a, 124b, 124c. These components 122a, 122b, 122c, 124a, 124b, 124c are preferably arranged within the secondary submodule 120, which is thermally separated from the primary submodule 110. Thus, only comparatively few components have to be provided in the primary submodule 110, i.e. the amplifier(s) 114 and optionally associated filters 116a, as well as antennas 112a (which may e.g. be provided at an outer surface of a housing 110' (Fig. 1b) of the primary submodule 110).

[0044] For example, the amplifier(s) 114 and optionally associated filters 116a may be provided on a so-called amplifier and filter card, which may e.g. comprise a printed circuit board or some other suitable substrate for the components 114, 116a.

[0045] According to a further embodiment, the antenna 112a (Fig. 1a) may be a single-band antenna, which is e.g. optimized for operation in a single RF band. Alternatively, the antenna 112a (Fig. 1a) may also be a multiband capable antenna (or wideband antenna), which is e.g. optimized for operation in several different RF bands. Likewise, according to a further embodiment, the amplifier unit 114 and associated filter 116a (or the amplifier and filter card, alternatively), may also be provided as single-band device or as a multi-band capable device.

[0046] According to a further embodiment, the primary submodule 110 and/or the secondary submodule 120 may be designed taking aspects of a heat sink into account (e.g., providing cooling fins at an outer surface of the housing 110', 120'). Alternatively or additionally, active cooling could be provided for either of the components 100, 110, 120, if required.

[0047] Advantageously, according to an embodiment, RF power amplifiers 114, 114a and associated filters 116a are arranged within the primary submodule 110.

[0048] According to an embodiment, all the remaining lower power electronics (converter 122a, 122b, 122c, modulator 124a, 124b, 124c, etc.) for TX, RX and feedback path are located on e.g. a further line-card outside the primary submodule 110, which forms the secondary submodule 120. According to a particularly preferred embodiment, the secondary submodule 120 is designed as a backplane card which may easily be attached to the primary submodule 110 e.g. by electric and/or optic connectors and the like, while preferably maintaining a thermal isolation between the components 110, 120.

[0049] According to a further embodiment, the components 122a, 124a, 122b, 124b, 122c, 124c of the secondary submodule 120 are preferably realized multiband (e.g., from about 400 MHz to about 4 GHz) and multistandard capable which make them applicable to primary submodules 110 addressing different frequencies. I.e., the multiband and/or multi-standard (e.g., 3G, 4G, 5G) capable secondary submodules 120 may be combined with primary submodules 110 of different types.

[0050] Advantageously, by providing the components 122a, 124a, 122b, 124b, 122c, 124c in the secondary submodule 120, and not in the primary submodule 110, the appearing dissipated power in the primary submodule 110 can be reduced as compared to conventional systems and the thermal situation can be improved.

[0051] A further advantage is that the secondary submodule 120, preferably implemented as a backplane card comprising one or more FPGAs, interface adaptation and lower power TX, RX and FB electronics, can be realized very broadband and applicable to primary submodules 110, each of which is optimized for addressing specific (partially different) frequencies and/or frequency ranges.

[0052] According to an embodiment, the primary submodules 110 are either single-band optimized or of limited multiband capability taking bandwidth - efficiency trade-off into account.

[0053] According to a further embodiment, a secondary submodule 120, especially in form of a wideband backplane card, can be equipped with one or more primary submodules 110 supporting different frequencies and/or frequency ranges. This means, the backplane card 120 is flexible with respect to carrier frequencies, and the supported frequencies and/or frequency ranges are defined by the primary submodules 110 attached to the backplane card 120.

[0054] A further advantage of the partitioning of the antenna module 100 into different submodules 110, 120 according to the embodiments is the possibility of improved heat removal especially relating to the primary submodule 110, since the heat of the amplifier and filter card (components 114a, 116a) doesn't have to be removed around the low power TX and RX electronics (components 122a, 124a, ..), since these elements are provided in the secondary submodule 120.

[0055] Furthermore, less electronics per submodule 110, 120 enables improved design of the submodule 110, 120 like a kind of cooling block, additionally supporting thermal characteristics.

[0056] According to an embodiment, in case of N many active antenna paths within one antenna system 1000 (Fig. 4), a backplane card may be provided which comprises N many universal, preferably low power, TX and RX cards, each implemented as a secondary submodule 120, which are each connected to an own primary submodule 110, the primary submodules 110 comprising an amplifier and filter card as well as an antenna. Thus N many primary submodules 110 are used for the antenna system according to the present embodiment.

[0057] According to a further embodiment, if a multiband capable active antenna array is to be realized, e.g. supporting two frequencies f1 and f2 or two frequency ranges, e.g. N/2 many of the active antenna array paths and low power TX and RX boards are equipped with primary submodules 110 supporting frequency (range) f1 and the remaining N/2 many active antenna array paths and thus low power TX and RX boards are equipped with primary submodules 110 supporting frequency (range) f2.

[0058] According to a further embodiment, if a primary submodule 110 is available supporting both f1 and f2 in a highly efficient manner, it is also possible to equip all active antenna paths with the same primary submodule of this type. By the described procedure, the active antenna array can also support more than two frequencies, e.g. by dedicated primary submodules 110 for the required frequencies or frequency ranges. Also, an unequal number of primary submodules 110 for the different frequencies is cogitable, e.g. less primary submodules 110 and thus transmit power for low frequencies than for high frequencies, since lower frequencies show improved coverage compared to higher frequencies.

[0059] The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope. Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

[0060] It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of illustrative circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

Claims

1. Antenna module (100) for a communications system,
wherein said antenna module (100) comprises a primary submodule (110), wherein said primary submodule (110) comprises one or more antennas (112a, 112b) and at least one amplifier unit (114) coupled with one of said antennas (112a, 112b), and wherein said antenna module (100) comprises a secondary submodule (120), wherein said secondary submodule (120) comprises at least one signal processing device (122), wherein said secondary submodule (120) is located outside of said primary submodule (110).

2. Antenna module (100) according to claim 1, wherein said primary submodule (110) comprises a housing (110') and wherein said secondary submodule (120) is arranged outside said housing (110') of said primary submodule (110).

3. Antenna module (100) according to one of the preceding claims, wherein primary cooling means (130) are provided which are thermally coupled with said primary submodule (110) or at least one component (114) thereof.

4. Antenna module (100) according to claim 3, wherein secondary cooling means are provided which are thermally coupled with said secondary submodule (120) or at least one component thereof, wherein said secondary cooling means are not thermally coupled with said primary submodule (110) or its primary cooling means (130).

5. Antenna module (100) according to one of the preceding claims, wherein said primary submodule (110) comprises a transmit path comprising a transmit amplifier (114a) and an associated transmit filter (116a), a receive path comprising a receive amplifier (114c) and an associated receive filter (116c), and wherein said primary submodule (110) optionally also comprises a feedback path, said feedback path

comprising a feedback amplifier (114b) and an associated feedback filter (116b).

6. Antenna module (100) according to one of the preceding claims, wherein said secondary submodule (120) comprises a first signal processing path for upconverting a transmit signal from a first frequency range to a second frequency range, and at least one further signal processing path for downconverting a receive signal and/or a feedback signal from a third frequency range to a fourth frequency range.

7. Antenna module (100) according to one of the preceding claims, wherein said secondary submodule (120) comprises at least one digital to analog converter (122a) and/or at least one analog to digital converter (122b, 122c).

8. Antenna module (100) according to one of the preceding claims, wherein said secondary submodule (120) comprises at least one digital interface for exchanging digital signals with at least one external device.

9. Antenna module (100) according to one of the preceding claims, wherein said secondary submodule (120) comprises at least one analog interface for exchanging analog signals with at least one external device, preferably with said primary submodule (110).

10. Antenna system (1000) comprising a plurality of antenna modules (100; 100a, 100b) according to one of the preceding claims, wherein at least two antenna modules (100; 100a, 100b) are configured to process radio frequency signals of same or different frequency ranges.

11. Antenna system (1000) according to claim 10, wherein a first number of antenna modules (100a) is provided which are configured to process radio frequency signals of a first frequency range, and wherein a second number of antenna modules (100b) is provided which are configured to process radio frequency signals of a second frequency range, wherein said second frequency range is different from said first frequency range.

Amended claims in accordance with Rule 137(2) EPC.

1. Antenna module (100) for a communications system, wherein said antenna module (100) comprises a primary submodule (110), wherein said primary submodule (110) comprises a housing (110') and one or more antennas (112a, 112b) and at least one amplifier unit (114) coupled with one of said antennas (112a, 112b), and wherein said antenna module (100) comprises a secondary submodule (120), wherein said secondary submodule (120) comprises at least one signal processing device (122), wherein said secondary submodule (120) is located outside of said housing (110') of said primary submodule (110).

2. Antenna module (100) according to claim 1, wherein primary cooling means (130) are provided which are thermally coupled with said primary submodule (110) or at least one component (114) thereof.

3. Antenna module (100) according to claim 2, wherein secondary cooling means are provided which are thermally coupled with said secondary submodule (120) or at least one component thereof, wherein said secondary cooling means are not thermally coupled with said primary submodule (110) or its primary cooling means (130).

4. Antenna module (100) according to one of the preceding claims, wherein said primary submodule (110) comprises a transmit path comprising a transmit amplifier (114a) and an associated transmit filter (116a), a receive path comprising a receive amplifier (114c) and an associated receive filter (116c), and wherein said primary submodule (110) optionally also comprises a feedback path, said feedback path comprising a feedback amplifier (114b) and an associated feedback filter (116b).

5. Antenna module (100) according to one of the preceding claims, wherein said secondary submodule (120) comprises a first signal processing path for upconverting a transmit signal from a first frequency range to a second frequency range, and at least one further signal processing path for downconverting a receive signal and/or a feedback signal from a third frequency range to a fourth frequency range.

6. antenna module (100) according to one of the preceding claims, wherein said secondary submodule (120) comprises at least one digital to analog converter (122a) and/or at least one analog to digital converter (122b, 122c).

7. Antenna module (100) according to one of the preceding claims, wherein said secondary submodule (120) comprises at least one digital interface for exchanging digital signals with at least one external device.

8. Antenna module (100) according to one of the preceding claims, wherein said secondary submodule (120) comprises at least one analog interface for exchanging analog signals with at least one external device, preferably with said primary submodule

(110).

9. Antenna system (1000) comprising a plurality of antenna modules (100; 100a, 100b) according to one of the preceding claims, wherein at least two antenna modules (100; 100a, 100b) are configured to process radio frequency signals of same or different frequency ranges.

10. Antenna system (1000) according to claim 9, wherein a first number of antenna modules (100a) is provided which are configured to process radio frequency signals of a first frequency range, and wherein a second number of antenna modules (100b) is provided which are configured to process radio frequency signals of a second frequency range, wherein said second frequency range is different from said first frequency range.

Fig. 1a

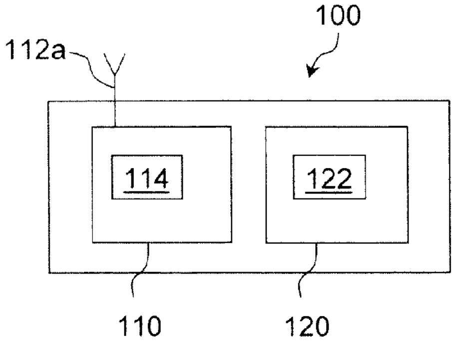


Fig. 1b

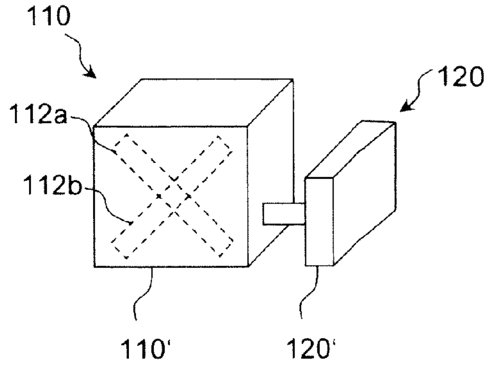


Fig. 2a

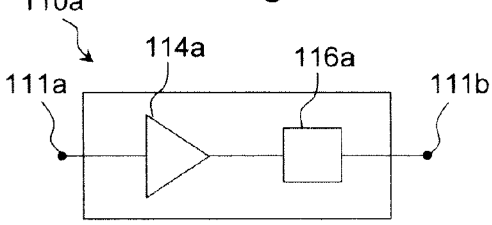


Fig. 2b

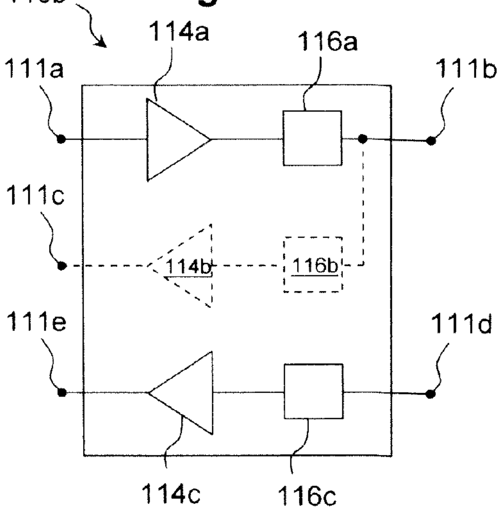


Fig. 3

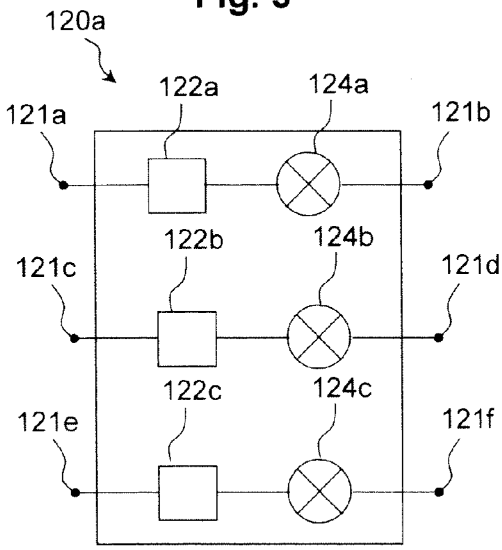


Fig. 4

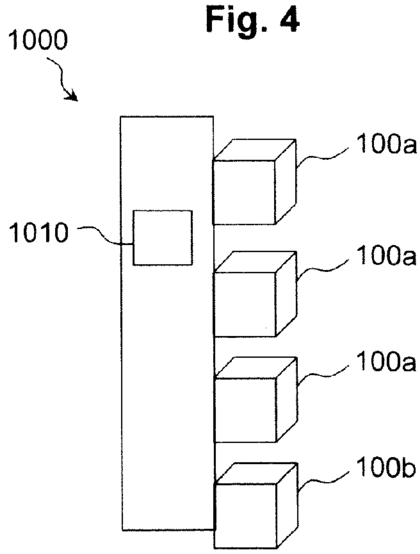
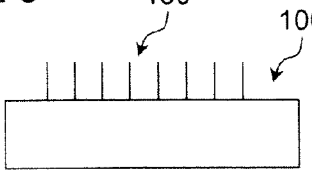


Fig. 5



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EUROPEAN SEARCH REPORT

Application Number
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Place of search	Date of completion of the search	Examiner
Munich	24 January 2014	Kaleve, Abraham

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