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(54) **An antenna arrangement having receiver diversity and a portable device comprising such an antenna arrangement**

(57) The present invention relates to antenna arrangement for a portable device, wherein the antenna arrangement comprises a main radiating element (1) and a diversity radiating element (2). The main radiating element (1) is configured to be tuned (4) to part of a receiving frequency band of said antenna arrangement, and the diversity radiating element (2) is configured to be tuned (5) to another part of the receiving frequency band.

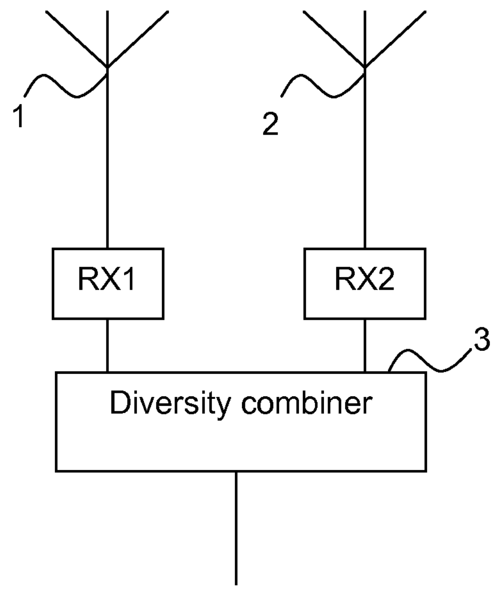

Fig. 1

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Description

FIELD OF INVENTION

[0001] The present invention relates generally to antennas, and particularly to an antenna arrangement for a portable device, having receiver diversity.

BACKGROUND

[0002] The market for portable radio communication devices, such as mobile phones, PDA, portable computers and similar devices, is today very competitive, which puts tough demands on the manufacturers. Furthermore, antennas of such devices many times only have access to limited space of different shapes.

SUMMARY OF THE INVENTION

[0003] An object of the present invention is thus to provide an antenna arrangement for a portable device which size can be reduced without reduced performance.

[0004] This object, among others, is according to the present invention attained by an antenna arrangement and a portable device, respectively, as defined by the appended claims.

[0005] By providing an antenna arrangement, for a portable device, comprising a main radiating element and a diversity radiating element, wherein the main radiating element is tuned to part of a receiving frequency band of said antenna arrangement, and that said diversity radiating element is tuned to another part of said receiving frequency band, the size of the antenna arrangement can be reduced without reduced performance, or could alternatively be made more efficient, than an original antenna. The bandwidth of an antenna is largely proportional to the volume of the antenna. However, the bandwidth of an antenna for a mobile phone-type of device is largely decided by the device size and in particular the length of the ground plane of the device. This means that when the size of radiating element in a portable device is halved, the available bandwidth is significantly more than half of the original bandwidth.

[0006] The antenna arrangement is preferably provided with the main radiating element and the diversity radiating element close to each other, so that their feeding points are not too far apart. This way, long transmission lines on the PCB are avoided. The antennas can be made of similar shape and size. However, to compensate for a higher relative bandwidth of the antenna covering the lower part of the frequency band, it can be made correspondingly larger. Further, by having the main radiating element and the diversity radiating element mirror positioned, the coupling there between can be reduced.

[0007] With e.g. mirrored radiating elements the main radiating element and the diversity radiating element can be arranged near each other in the portable device, without having too high coupling there between. The main radiating element and diversity radiating element are preferably arranged in the same half of the portable device in order to avoid unnecessary transmission lines, and to provide the possibility to place metal covers on the device. Metal covers are often used for design and user feeling purposes. However, it is not possible to place antennas under a metal shield, why it is important to keep the area occupied by antennas as small as possible.

[0008] When the part of a receiving frequency band of the main radiating element and the part of the receiving frequency band of the diversity radiating element are distinct apart and they together constitute not fully the receiving frequency band of the antenna arrangement the size of the antenna arrangement can be reduced further compared to an original antenna.

[0009] The matching specification in band can be typically -6 dB, for the RX band. A matching of -6 dB means that about 1.2 dB power is lost due to mismatch losses. With the matching diversity feature according to the present invention, the matching requirement for the RX band can be significantly relaxed.

[0010] There exists several diversity combining techniques. The preferred one to be used in an antenna arrangement according to the present invention is Maximum Ratio Combining (MRC), where each antenna branch is scaled with an amplitude and phase in order to maximize the resulting Signal-to-noise ratio (SNR). As shown in Jakes, W. C. "Microwave Mobile Communications", AT&T IMP Corp, 1974, IEEE press reissue, equation 5.2-12, with the correct scaling, the resulting SNR is the sum of the incoming SNR:s. Assuming that the main and diversity antennas have the same radiation efficiencies, the difference in performance is defined by the mismatch loss as described above.

[0011] If the matching of an antenna is -3dB, about 3dB is lost in mismatch loss, i.e. half of the power is reflected, half is transferred to the receiver. Using two antennas in the MRC diversity system, each having -3dB matching, the resulting SNR would be the same as of an ideal matched antenna, i.e. 0 dB mismatch loss.

[0012] From the above, it can be understood that also an antenna with poor matching can contribute and improve the RX performance of the antenna arrangement.

[0013] Note that the above reasoning holds for antennas receiving fully correlated signals, e.g. in an anechoic chamber which is useful for type approval testing in the lab. The preferred way to utilize antenna diversity is to design the antennas to receive uncorrelated signals in a multi-path environment. In this case, the diversity gain would be even larger than described above.

[0014] Further features and advantages of the present invention will be evident from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The present invention will become more fully understood from the detailed description of embodiments given below and the accompanying figures, which are given by way of illustration only, and thus, are not limitative of the present invention, wherein:

Fig. 1 schematically illustrates an antenna arrangement according to the present invention.

Fig. 2 shows a diagram of the reflection coefficient for an antenna arrangement according to the present invention.

Fig. 3 shows a diagram of the total efficiency for an antenna arrangement according to the present invention.

Fig. 4 schematically illustrates positioning of radiating elements over a ground plane device according to the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0016] In the following description, for purpose of explanation and not limitation, specific details are set forth, such as particular techniques and applications in order to provide a thorough understanding of the present invention. However, it will be apparent for a person skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed description of well-known methods and apparatuses are omitted so as not to obscure the description of the present invention with unnecessary details.

[0017] An antenna arrangement according to the present invention will now be described with reference to Figs. 1-4.

[0018] The antenna arrangement comprises a main radiating element 1 and a diversity radiating element 2, and is arranged in a portable device, such as a mobile phone, a PDA, a portable computer or similar device. The portable device further comprises a first receiver circuit RX1 and a second receiver circuit RX2, connected to the main radiating element 1 and the diversity radiating element 2, respectively. The receiver circuits RX1 and RX2 are in turn connected to a diversity combiner 3.

[0019] Signals received by the main radiating element 1 are fed to the receiver circuit RX1, and signals received by the diversity radiating element 2 are fed to the receiver circuit RX2. The outputs from the receiver circuits RX1 and RX2 are thereafter combined in the diversity combiner 3.

[0020] The antenna arrangement is in this embodiment configured to operate at the DVB-H frequency band, i.e. cover reception for 470 MHz - 750 MHz, where the upper limit is set to 750 MHz in order to give some distance to GSM transmit signals that easily interfere with the DVB-H signal (this relaxation of the DVB-H bandwidth is commonly done in mobile phones). The operating band is divided into RX band 1 and RX band 2, which bands together make up the DVB-H operating band. The RX band 1 preferably covers 470 MHz - 610 MHz, and RX band 2 preferably covers 610 MHz - 750 MHz. The division of the operating band is alternatively divided into other proportions. There can be an advantage in letting Rx band 1 have a narrower bandwidth, since the relative bandwidth for this band is higher compared to Rx band 2, even if the absolute bandwidths are the same. By letting Rx band 1 be narrower and Rx band 2 correspondingly broader, the design challenge of the two radiating elements can be equalized. The main radiating element 1 is configured to be tuned 4 to partly match the receiving frequency band RX1 of the operating band of the antenna arrangement, and the diversity radiating element 2 is arranged to be tuned 5 to partly match the receiving frequency band RX2 of the operating band of the antenna arrangement.

[0021] The part 4 of the receiving frequency band RX band 1 covered by the main radiating element 1 and the part 5 of the receiving frequency band RX band 2 covered by the diversity radiating element 2 are preferably distinct apart, i.e. utilizing a relaxed S_{11} requirement to reduce the size of the antenna arrangement. The total coverage of the receiving frequency band RX1 and RX2 from the main radiating element 1 and the diversity radiating element 2 is thus not fulfilled, which however is compensated by the receiver diversity gain.

[0022] By being tuned to a frequency band is meant that the S_{11} requirements for the antenna arrangement is fulfilled for that frequency band. Note that for DVB-H, the S_{11} requirements are rather relaxed compared to cellular requirements, such as e.g. for GSM.

[0023] The diversity radiating element 2 is preferably positioned relatively near the main radiating element 1 in the portable device, such as at the same half of the portable device instead of opposing parts thereof. This positioning of the main radiating element 1 and the diversity radiating element provides the following advantages. By both radiating elements being positioned close to RF circuits, which typically are placed in one shielded area of the portable device, there is no need for long RF transmission lines on the printed circuit board of the portable device. Also, metal covers can be used at all places where there is no antenna, and with both the main radiating element 1 and the diversity radiating element 2 in a tight area a larger portion of the portable device can be provided with a metal cover. Positioning of the radiating elements partly off-ground in top portion of the portable device is illustrated in Fig. 4, wherein the radiating elements protrude out from a ground plane device, such as a printed wiring board of the portable device.

[0024] The diversity combiner 3 is preferably based on Maximum Rating Combination MRC, as described above, with improved instantaneous and average signal as a result. Fig. 3 illustrates the performance of the individual antennas and the diversity combined result (MRC). The left axis shows the total antenna efficiency, which is mainly decided by mismatch loss. Since the individual antennas have a rather narrow bandwidth, the performance drops fast when going away from the center frequencies, which is where the performance peaks. In between the antenna center frequencies, both antennas have relatively poor match, and the diversity combined signal gives the best gain compared to the individual antennas. Note that the "total efficiency" for the MRC combined antenna plotted in Fig. 3 should be interpreted as the equivalent total efficiency of a single antenna having the same performance as the MRC combined signal from the antenna and the diversity antenna.

[0025] The radiating elements are e.g. implemented as meandering IFA elements positioned partly off-ground. The partly off-ground position provides a wider bandwidth while keeping the dimensions of the antenna small. Alternatively, the radiating elements can e.g. be patch elements (PILA or PIFA). To achieve a good antenna performance at the low frequencies required by the DVB-H system, a matching network is typically required. The matching network tunes the antenna resonance down in frequency and also provides a good match to 50 ohm.

[0026] A matching network for the main radiating element 1, being tuned to RX band 1, is e.g. a big inductor in series and a parallel match, comprising an inductor and a capacitor, creating a dual resonance. By alternating the components and also the layout for the matching circuit, two identical, and preferably mirrored, antenna elements can be tuned to individual parts of the DVB-H band, i.e. Rx band 1 and Rx band 2.

[0027] Although a single operating band have been described above, the same principle with part of the receiving frequency band covered by a narrow band radiating element separate from the main radiating element covering another part of the receiving frequency band can be applied to multiple operating bands. The operating bands could thus be e.g. DVB-H, GSM900, GSM1800, GSM1900, Bluetooth or WLAN and UWB. It is also possible to utilize more radiating elements then the two described above.

[0028] It will be obvious that the present invention may be varied in a plurality of ways. Such variations are not to be regarded as departure from the scope of the present invention as defined by the appended claims. All such variations as would be obvious for a person skilled in the art are intended to be included within the scope of the present invention as defined by the appended claims.

Claims

1. An antenna arrangement for a portable device, wherein said antenna arrangement comprises a main radiating element (1) and a diversity radiating element (2), **characterized in that** said main radiating element (1) is configured to be tuned (4) to part of a receiving frequency band of said antenna arrangement, and that said diversity radiating element (2) is configured to be tuned (5) to another part of said receiving frequency band.

2. An antenna arrangement as claimed in claim 1, wherein said part of a receiving frequency band of said main radiating element (1) and said another part of said receiving frequency band of said diversity radiating element (2) are distinct apart.

3. The antenna arrangement as claimed in claim 2, wherein said main radiating element is configured to be tuned to fulfill matching requirements at the lowest part of said receiving frequency band and said diversity radiating element is configured to be tuned to fulfill matching requirements at the highest part of said receiving frequency band.

4. The antenna arrangement as claimed in claim 3, wherein said main radiating element and said diversity radiating element are configured to be tuned to not fulfill matching requirements between said lowest part and said highest part of said receiving frequency band..

5. The antenna arrangement as claimed in any of claims 1-4, wherein said part of a receiving frequency band of said main radiating element (1) and said another part of said receiving frequency band of said diversity radiating element (2) together not fully cover said receiving frequency band of said antenna arrangement.6. The antenna arrangement as claimed in any of claims 1-5, wherein said main radiating element (1) and said diversity radiating element (2) are arranged near each other in said portable device.

7. The antenna arrangement as claimed in any of claims 1-6, wherein said main radiating element (1) and diversity radiating element (2) are arranged in the same half of said portable device.

8. The antenna arrangement as claimed in any of claims 1-7, wherein said receiving frequency band is the DVB-H operating band.

9. The antenna arrangement as claimed in any of claims 1-8, wherein said main radiating element (1) and said diversity radiating element (2) have similar shape.

10. The antenna arrangement as claimed in any of claims 1-9, wherein said main radiating element (1) and said diversity radiating element (2) are mirror positioned.

11. A portable device **characterized in that** is comprises an antenna arrangement as claimed in any of claims 1-10.

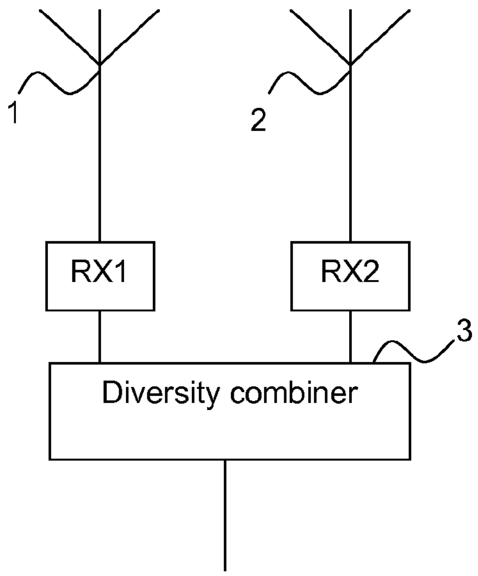
1
2
RX1
RX2
3
Diversity combiner

Fig. 1

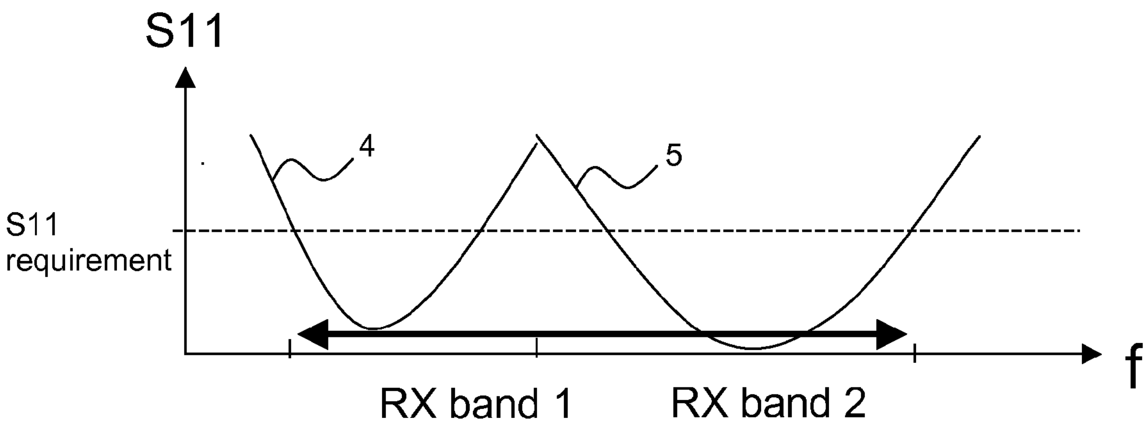
S11
4
5
S11
requirement
f
RX band 1
RX band 2

Fig. 2

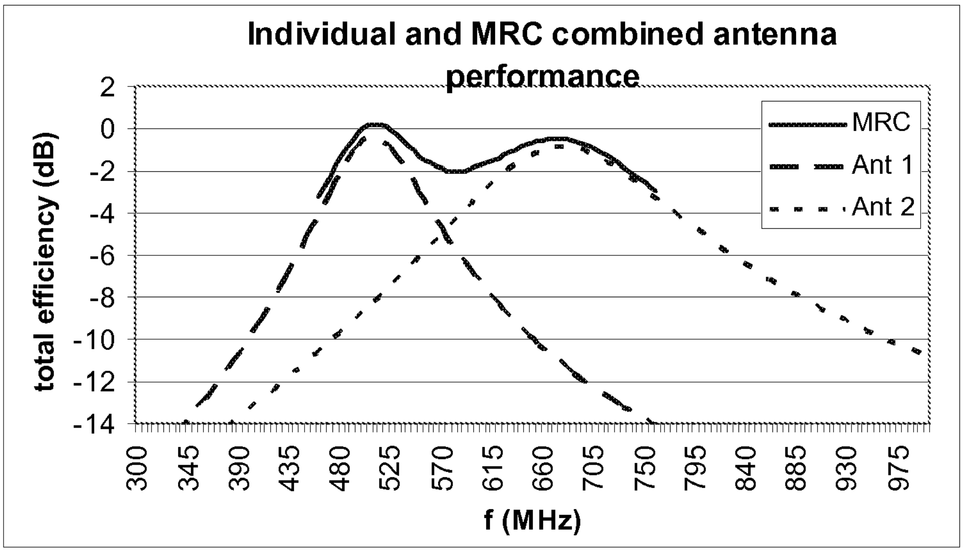
Individual and MRC combined antenna performance
total efficiency (dB)
2
0
-2
-4
-6
-8
-10
-12
-14
300
345
390
435
480
525
570
615
660
705
750
795
840
885
930
975
f (MHz)
MRC
Ant 1
Ant 2

Fig. 3

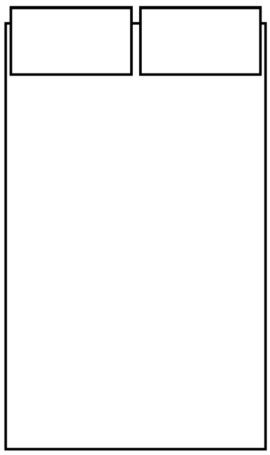

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 08 15 6910

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 1 885 022 A (MATSUSHITA ELECTRIC IND CO LTD [JP] PANASONIC CORP [JP]) 6 February 2008 (2008-02-06) * abstract; figure 1 * * paragraphs [0031] - [0033] * * paragraphs [0036] - [0040] * -----	1-8,11 9,10	INV. H01Q1/24 H01Q21/28
Y	US 2003/058174 A1 (SUNG JAE-SUK [KR]) 27 March 2003 (2003-03-27) * paragraph [0037]; figures 3b,4 * -----	9,10	
A	WO 02/05382 A (ALLGON AB [SE]; RUTFORS TOMAS [SE]; BRAUN CHRISTIAN [SE]; FALKEN HENRI) 17 January 2002 (2002-01-17) * abstract * * page 4, line 1 - page 5, line 30 * -----	1-11	
A	WO 2007/138157 A (PULSE FINLAND OY [FI]; NISSINEN PERTTI [FI]; ANNAMAA PETTERI [FI]) 6 December 2007 (2007-12-06) * abstract; figures 3,6 * * page 4, line 12 - page 5, line 23 * * page 7, lines 17-22 * -----	1-11	TECHNICAL FIELDS SEARCHED (IPC) H01Q
A	WO 2004/077610 A (RES IN MOTION LTD [CA]; MAN YING TONG [CA]; QI YIHONG [CA]; JARMUSZEWS) 10 September 2004 (2004-09-10) * abstract; figures 1-3,6-8 * * page 4, line 1 - page 5, line 16 * * page 8, line 18 - page 10, line 14 * -----	1-11	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	3 April 2009	Unterberger, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 15 6910

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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03-04-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1885022 A	06-02-2008	CN 101107749 A	16-01-2008
		JP 2006325133 A	30-11-2006
		WO 2006123790 A1	23-11-2006
		US 2009023396 A1	22-01-2009
US 2003058174 A1	27-03-2003	JP 2003124729 A	25-04-2003
		KR 20030028645 A	10-04-2003
WO 0205382 A	17-01-2002	AT 348412 T	15-01-2007
		AU 6966601 A	21-01-2002
		CN 1457528 A	19-11-2003
		DE 60125182 T2	20-09-2007
		EP 1305844 A1	02-05-2003
		SE 516842 C2	12-03-2002
		SE 0002600 A	11-01-2002
		US 2004051669 A1	18-03-2004
WO 2007138157 A	06-12-2007	EP 2022140 A1	11-02-2009
		FI 118837 B1	31-03-2008
WO 2004077610 A	10-09-2004	AU 2003208207 A1	17-09-2004
		US 2004257291 A1	23-12-2004

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- Microwave Mobile Communications. **Jakes, W. C.** AT&T IMP Corp. IEEE press, 1974 **[0010]**