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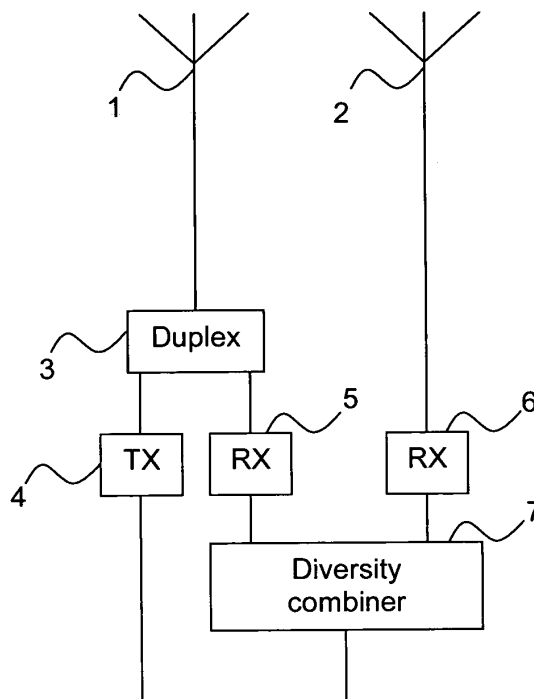
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(54) **An antenna device having receiver diversity and a portable radio communication device comprising such an antenna device**

(57) The present invention relates to antenna device for a portable radio communication device, wherein the antenna device comprises a main radiating element (1) and a diversity radiating element (2). The main radiating element (1) is tuned (8; 11) to a transmitting frequency band of the antenna device and is tuned (8; 11) to part of a receiving frequency band of the antenna device corresponding to the transmitting frequency band, and that the diversity radiating element is tuned (9) to part of the receiving frequency band.



**Fig. 1**

## Description

### FIELD OF INVENTION

[0001] The present invention relates generally to antennas, and particularly to an antenna device for a portable radio communication 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 device for a portable radio communication device which size can be reduced without reduced performance.

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

[0005] By providing an antenna device, for a portable radio communication device, comprising a main radiating element and a diversity radiating element, wherein the main radiating element is tuned to a transmitting frequency band of the antenna device and is tuned to part of a receiving frequency band of the antenna device corresponding to the transmitting frequency band, and the diversity radiating element is tuned to part of the receiving frequency band, the size of the antenna device can be reduced without reduced performance. By having a transmitting antenna element and diversity reception utilizing partly the transmitting antenna element and a diversity receiving element the total antenna size is smaller, or could alternatively be made more efficient, than an original antenna.

[0006] The part of a receiving frequency band of the main radiating element is preferably closer to the transmitting frequency band compared to the part of the receiving frequency band of the diversity radiating element, whereby performance can be improved. Further, even 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 device the size of the antenna device can be reduced compared to an original antenna.

[0007] The matching specification in band can be typically -6 dB, both for the Tx band and 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.

[0008] There exists several diversity combining techniques. The preferred one to be used in an antenna device 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.

[0009] 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.

[0010] From the above, it can be understood that also an antenna with poor matching can contribute and improve the Rx performance of the antenna system.

[0011] 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.

[0012] By preferably providing the main radiating element to be matched in the center of the transmitting frequency band the size of the antenna device can be further reduced without reduced performance, which matching preferably is arranged to be adaptively performed.

[0013] Further features and advantages of the present invention will be evident from the following description.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0014] 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 functionality of a first embodiment of the present invention.

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

Fig. 3 schematically illustrates functionality of a second embodiment of the present invention.

Fig. 4 shows a diagram of the reflection coefficient for an antenna device according to the second embodiment of the present invention.

## DETAILED DESCRIPTION OF EMBODIMENTS

**[0015]** 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.

**[0016]** A first embodiment of the present invention will now be described with reference to Figs. 1-2.

**[0017]** An antenna device for a portable radio communication device, such as mobile phones, PDA, portable computers and similar devices, comprises a main radiating element 1 and a diversity radiating element 2. The main radiating element 1 is arranged to be tuned 8 to the transmitting frequency band TX of an operating band of the antenna device, such as GSM900, and to partly match the corresponding receiving frequency band RX of the operating band of the antenna device. The diversity radiating element 2 is arranged to be tuned 9 to partly match the corresponding receiving frequency band RX. For e.g. GSM900 the main radiating element 1 would receive strongest signals in the lower part of the receiving frequency band RX of the antenna device and the diversity radiating element 2 would receive strongest signals in the upper part of the receiving frequency band TX of the antenna device.

**[0018]** The part 8 of the receiving frequency band RX covered by the main radiating element 1 and the part 9 of the receiving frequency band RX 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 device. The total coverage of the receiving frequency band RX from the main radiating element 1 and the diversity radiating element 2 is thus not fulfilled, which however is compensated by the receiver diversity.

**[0019]** By being tuned to a frequency band is meant that the  $S_{11}$  requirements for the antenna device is fulfilled for that frequency band.

**[0020]** Signals transmitted from the antenna device go through the main radiating element 1 via a transmitter circuit 4 and a duplexer 3. Signals received at the antenna device go through the main radiating element 1, the duplexer 3, and a receiver circuit 5 and is combined in a diversity combiner 7 with signals that go through the diversity radiating element 2 and its separate receiver circuit 6.

**[0021]** The diversity radiating element 2 is preferably positioned relatively near the main radiating element 1

in the portable radio communication device, such as at the same half of the portable radio communication device instead of opposing parts thereof. This positioning gets the following advantages. By being positioned closer to RF circuits, that are typically placed in one shielded area of the portable radio communication device, there is no need for long RF transmission lines on the printed circuit board of the portable radio communication device. Also, metal covers can be used at all places where there is no antenna, and with both main antenna and diversity antenna in a tight area a larger portion of the portable radio communication device can be provided with a metal cover.

**[0022]** A second embodiment of the present invention will now be described with reference to Figs. 3-4. This second embodiment of the present invention is identical with the first embodiment described above, apart from the following. The main radiating element 1 is an active antenna element with adaptive matching 10, which adaptively tunes 11 the center 13 of the matching into the TX channel currently used, but which matching still partly covers the RX band.

**[0023]** Adaptive matching system for antennas uses a narrowband antenna element that is tuned to the specific channel used at the moment. Typically the tuning is optimized to the Tx channel, since it is straightforward to measure the matching for the Tx channel (reflected power meter). With only one antenna, it will be challenging to get the Rx performance in place. With a diversity receiving antenna the tuning of the Tx channel is more easily achieved by taking no or only little regard to the Rx channel for the main antenna, since this can be handled by the diversity receiving antenna.

**[0024]** 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 part of the receiving frequency band and the transmitting band can be applied to multiple operating bands. The main radiating element would thus be tuned to TX for e.g. GSM900 and GSM1800 and partly tuned to RX for GSM900 and GSM1800, whereas the diversity radiating element would be partly tuned to RX for GSM900 and GS1800.

**[0025]** 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.

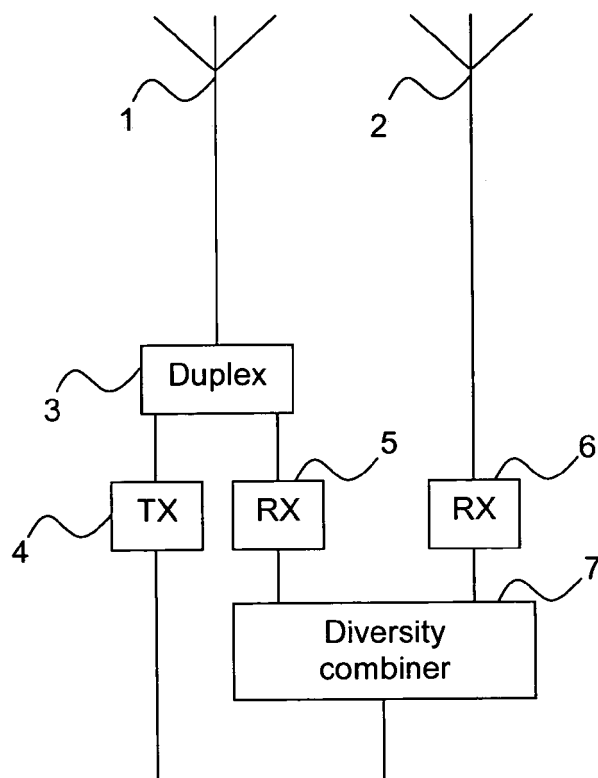
## Claims

1. An antenna device for a portable radio communication device, wherein said antenna device comprises a main radiating element (1) and a diversity radiating

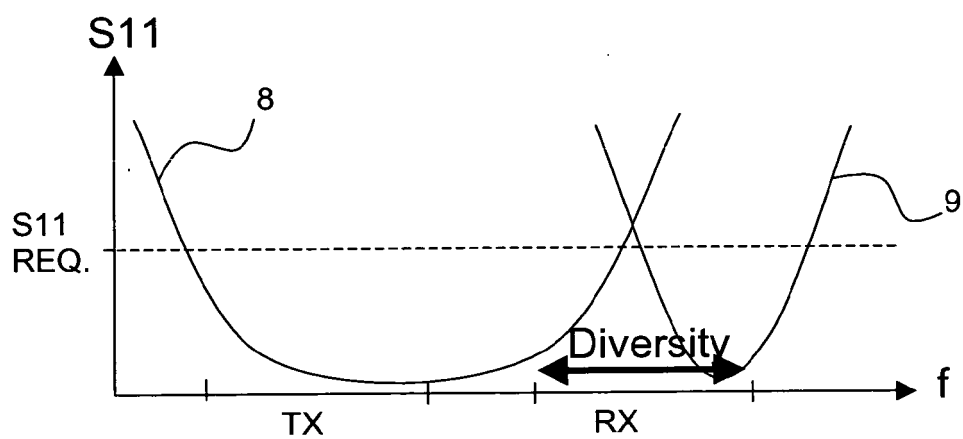
element (2), **characterized in that** said main radiating element (1) is tuned (8; 11) to a transmitting frequency band of said antenna device and is tuned (8; 11) to part of a receiving frequency band of said antenna device corresponding to said transmitting frequency band, and that said diversity radiating element is tuned (9) to part of said receiving frequency band.

2. The antenna device as claimed in claim 1, wherein said part of a receiving frequency band of said main radiating element (1) is closer to said transmitting frequency band compared to said part of said receiving frequency band of said diversity radiating element (2). 5
3. An antenna device as claimed in claims 1 or 2, wherein said part of a receiving frequency band of said main radiating element (1) and said part of said receiving frequency band of said diversity radiating element (2) are distinct apart in said receiving frequency band of said antenna device. 10
4. The antenna device as claimed in any of claims 1-3, wherein said part of a receiving frequency band of said main radiating element (1) and said part of said receiving frequency band of said diversity radiating element (2) together not fully cover said receiving frequency band of said antenna device. 15
5. The antenna device as claimed in any of claims 1-4, wherein said main radiating element (1) is tuned (11) such that it is centered (13) to the specific Tx channel in said transmitting frequency band of said antenna device. 20
6. The antenna device as claimed in claim 5, wherein said tuning is arranged to be adaptively performed. 25
7. The antenna device as claimed in any of claims 1-6, wherein said main radiating element (1) and diversity radiating element (2) are arranged near each other in said portable radio communication device. 30
8. The antenna device as claimed in any of claims 1-7, wherein said main radiating element (1) and diversity radiating element (2) are arranged in the same half of said portable radio communication device. 35
9. A portable radio communication device **characterized in that** is comprises an antenna device as claimed in any of claims 1-8. 40

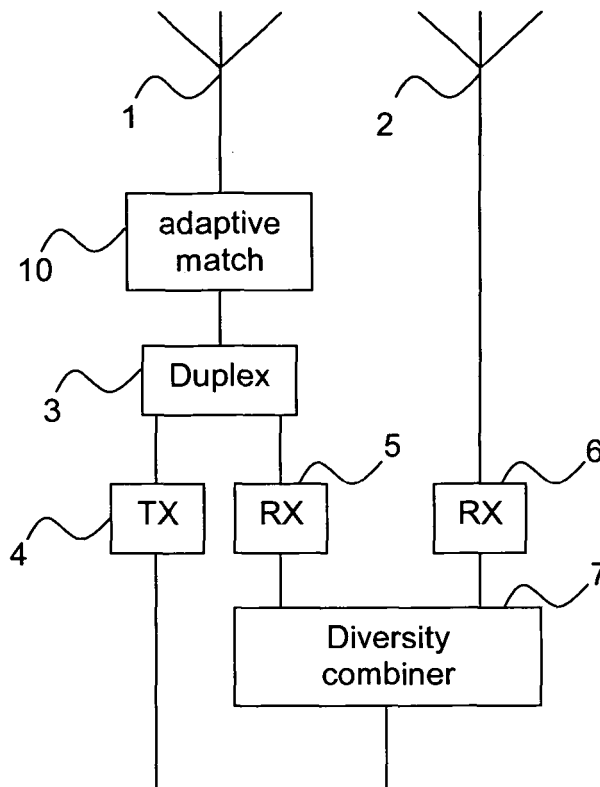
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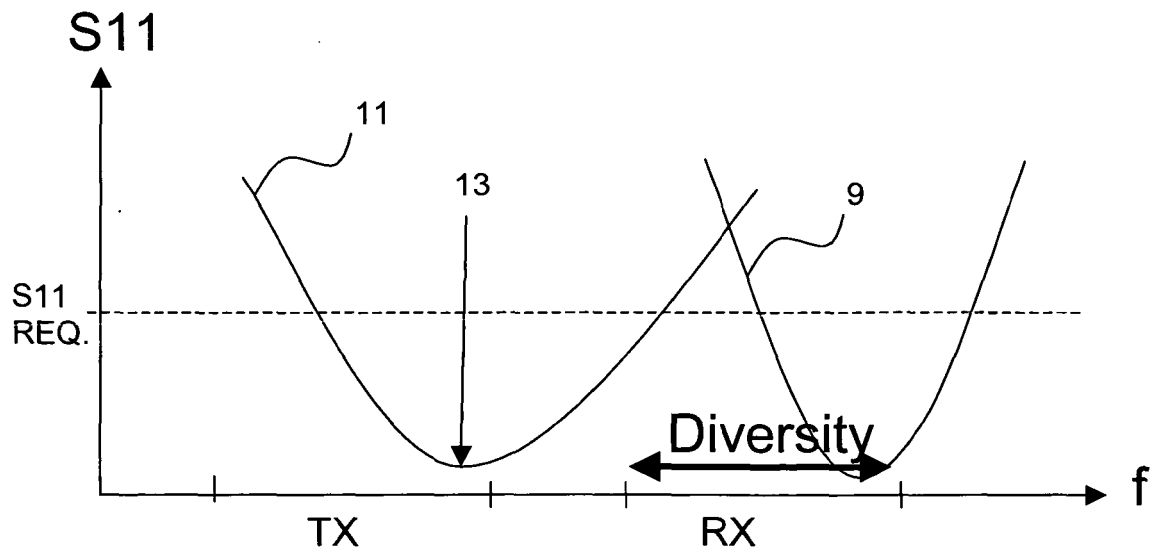
**Fig. 1**



**Fig. 2**



**Fig. 3**



**Fig. 4**



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 08 44 5015

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	US 2003/058174 A1 (SUNG JAE-SUK [KR]) 27 March 2003 (2003-03-27) * abstract; figures 2a,2b,3b * * paragraphs [0025] - [0030], [0037] * -----	1-9	INV. H01Q21/28 H01Q21/30 H01Q1/24
A	EP 1 475 858 A (MATSUSHITA ELECTRIC IND CO LTD [JP]) 10 November 2004 (2004-11-10) * abstract; figure 4 * * paragraphs [0055] - [0062] * -----	1-9	
A	EP 0 332 139 A (TOYODA CHUO KENKYUSHO KK [JP]) 13 September 1989 (1989-09-13) * figures 1-3 * * column 5, line 33 - column 6, line 39 * -----	1-9	
A	US 7 298 339 B1 (OLLIKAINEN JANI [FI]) 20 November 2007 (2007-11-20) * figures 1,2 * * column 4, line 26 - column 5, line 7 * -----	1-9	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01Q
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 June 2008	Examiner Unterberger, Michael
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... &amp; : member of the same patent family, corresponding document</p>			

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 44 5015

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
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20-06-2008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003058174 A1	27-03-2003	JP 2003124729 A	25-04-2003
		KR 20030028645 A	10-04-2003
-----			
EP 1475858 A	10-11-2004	AU 2003211999 A1	04-09-2003
		CN 1633735 A	29-06-2005
		WO 03069727 A1	21-08-2003
		JP 3608735 B2	12-01-2005
		JP 2003243916 A	29-08-2003
		US 2006017624 A1	26-01-2006
-----			
EP 0332139 A	13-09-1989	CA 1313408 C	02-02-1993
		DE 68909072 D1	21-10-1993
		DE 68909072 T2	24-03-1994
		JP 1231404 A	14-09-1989
		JP 1942242 C	23-06-1995
		JP 6059009 B	03-08-1994
		US 4907006 A	06-03-1990
-----			
US 7298339 B1	20-11-2007	WO 2008001167 A1	03-01-2008
-----			



**REFERENCES CITED IN THE DESCRIPTION**

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**Non-patent literature cited in the description**

- Microwave Mobile Communications. **Jakes, W. C.**  
AT&T IMP Corp. IEEE press, 1974 [0008]