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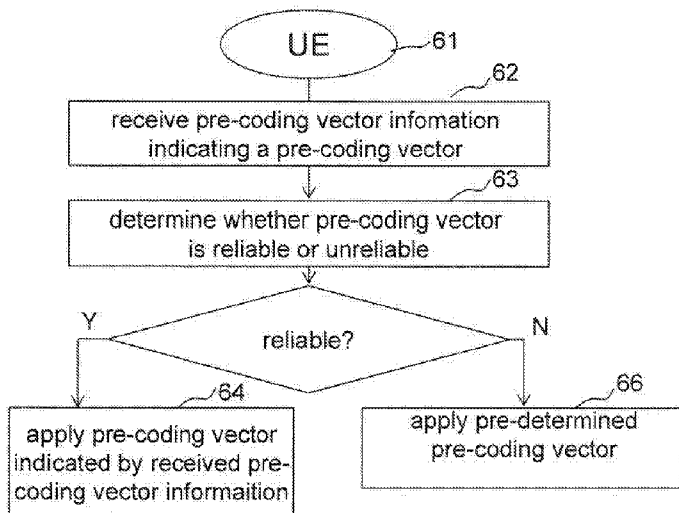


Fig. 5

(57) Abstract: The disclosure relates to controlling uplink transmissions according to closed loop techniques such as closed loop uplink transmit diversity and uplink multiple-input multiple-output (MIMO). An exemplary method for use in a user equipment (61) configured for multi-antenna transmissions comprises a step of receiving (62), in a downlink channel, pre-coding vector information indicating a pre-coding vector for uplink transmission. The method further comprises a step of determining (63) whether the pre-coding vector indicated by the received pre-coding vector information is reliable or unreliable and steps of applying (64) the pre-coding vector indicated by the received pre-coding vector information for uplink transmission only if the pre-coding vector is determined to be reliable and applying (66) a pre-determined pre-coding vector when the pre-coding vector indicated by the received pre-coding vector information is determined to be unreliable.

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CONTROLLING UPLINK MULTI-ANTENNA TRANSMISSIONS IN A TELECOMMUNICATION SYSTEM

5 TECHNICAL FIELD

The embodiments described herein relate to controlling uplink multi-antenna transmissions in a telecommunication system and in particular to methods and devices for closed loop solutions such as closed loop uplink transmit diversity and uplink multiple-input multiple-output (MIMO).

10

BACKGROUND

There is a continuous development of new generations of mobile communications technologies to cope with increasing requirements of higher data rates, improved efficiency and lower costs. High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA), together referred to as High Speed Packet Access (HSPA), are mobile communication protocols that were developed to cope with higher data rates than original Wideband Code Division Multiple Access (WCDMA) protocols were capable of. The 3rd Generation Partnership Project (3GPP) is a standards-developing organization that is continuing its work of evolving HSPA and creating new standards that allow for even higher data rates and improved functionality.

In a radio access network implementing HSPA, a user equipment (UE) is wirelessly connected to a base station commonly referred to as a NodeB (NB). A base station is a general term for a radio network node capable of transmitting radio signals to a UE and receiving signals transmitted by a UE.

Recently 3GPP has started a number of work items targeting uplink multi-antenna solutions for a standard release 11. In particular, there are work items targeted for open and closed loop uplink transmit diversity as well as a study item on uplink multiple-input-multiple-output (MIMO) transmission.

With uplink transmit diversity, UEs that are equipped with two or more transmit antennas are capable of utilizing all of them for uplink transmissions. This is

achieved by multiplying a UE output signal with a set of complex pre-coding weights, a so-called pre-coding vector with one pre-coding weight for each physical transmit antenna. The rationale behind uplink transmit diversity is to adapt the pre-coding weights so that user equipment and network performance is maximized. Depending on UE implementation the antenna pre-coding weights may be associated with different constraints. Within 3GPP two classes of transmit diversity are considered:

- Switched antenna transmit diversity, where the UE at any given time-instance transmits from one of its antennas only.
- Beamforming where the UE at a given time-instance can transmit from more than one antenna simultaneously. By means of beamforming it is possible to shape an overall antenna beam in the direction of a target receiver. It can be noted that switched antenna transmit diversity can be seen as a special case of beamforming where one of the pre-coding weights is 1 (i.e. switched on) and the pre-coding weight of any other antenna of the UE is 0 (i.e. switched off).

Transmit diversity schemes can be seen as a generic framework for mapping symbols to antenna ports. With respect to beamforming techniques, rank-1 transmissions, the same symbols are mapped to the several physical antennas and by adapting the pre-coding vector so that it matches the "radio" channel the UE and network performance, e.g., coverage, throughput, transmit power, etc., can be improved. More specifically, this is achieved by multiplying the signal with a set of complex weights w_i , one for each physical antenna. Mathematically, this can be written as follows

$$\begin{bmatrix} y_1 \\ \vdots \\ y_N \end{bmatrix} = \begin{bmatrix} w_1 \\ \vdots \\ w_N \end{bmatrix} s = \mathbf{W} s$$

where y_l is the signal at the l th antenna port and where w is typically referred to as the pre-coding or beamforming vector. As noted above the fundamental idea with uplink transmit diversity is to exploit the properties in the effective channel and ensure that coherent combining is achieved at the receiver. The term effective channel here incorporates effects of transmit and receive antennas as well as the radio channel between the transmitting and receiving antennas.

For uplink MIMO, different data is transmitted from different virtual antennas in so-called streams. Each virtual antenna corresponds to a different pre-coding vector. Note that closed loop beamforming can be viewed as a special case of uplink MIMO where no data is scheduled on all but one of the possible virtual antennas.

MIMO technology is mainly beneficial in situations where the "composite channel" is strong and has high rank. The term composite channel includes the potential effects of transmit antenna(s), power amplifiers (PAs), as well as the radio channel between the transmitting and receiving antennas. The rank of the composite channel depends on the number of uncorrelated paths between the transmitter and the receiver. Single-stream transmissions, i.e. beamforming techniques, are generally preferred over MIMO transmissions in situations where the rank of the composite channel is low e.g. where there is a limited amount of multi-path propagation and cross polarized antennas are not used, and/or the path gain between the UE and the NodeB is weak.

In closed-loop techniques, such as closed loop transmit diversity or uplink MIMO, the network decides or recommend the pre-coding vector(s) that the UE should apply by means of a physical channel. One example of such a physical channel would be to rely on a Fractional Dedicated Physical Channel (F-DPCH)-like channel or a grant channel, such as an Enhanced Dedicated Channel Absolute Grant Channel (E-AGCH)-like or an Enhanced Dedicated Channel Relative Grant Channel (E-RGCH)-like channel. A serving NodeB could e.g. signal a recommended pre-coding vector to a UE on the physical channel by means of an explicit or implicit indication of the recommended pre-coding vector(s).

The terms "pre-coding vector information", "pre-coding information" and "feedback information" are used synonymously herein to refer to information transmitted on the above mentioned physical channel in order for the network to indicate pre-coding weights/one or several pre-coding vectors that a UE is recommended to use for uplink transmission. Pre-coding vector information that recommends pre-coding vector(s) to a UE may also be referred to as a "pre-

coding command". The term "pre-coder" is used herein to refer to a set of pre-coding weights which can comprise one or several pre-coding vectors.

5 Regardless of the physical channel that is used to signal feedback from the network to the UE one key aspect of closed-loop schemes is that a sufficient reception quality of the feedback quality can be ensured. In fact as the reception quality of the physical channel carrying the feedback information deteriorates the reliability of the signaled pre-coding vector(s) becomes increasingly unreliable and at some point the usage of closed loop beamforming or uplink MIMO may
10 become harmful. This is because the UE will, in case of unreliable pre-coding commands, start to direct its beam in a random direction which may cause excessive amounts of interference in neighboring cells. Moreover, the variations in interference will become more rapid. Also, the performance and Rise-over-Thermal (RoT) utilization may be reduced because the received power from a
15 given UE will experience faster variations due to the rapid changes in the pre-coding weights. Consequently, inner loop power control may be unable to track the channel at low Doppler spreads.

20 Another design choice related to closed loop transmit diversity schemes and MIMO schemes is the physical channel structure and more specifically which physical channels that should be multiplied with the pre-coding vector. According to an example architecture one of the pilots transmitted on a Dedicated Physical Control Channel (DPCCH) and all of the other physical channels are transmitted using a certain pre-coding vector, often referred to as
25 the primary pre-coding vector. The other pilot transmitted on the other DPCCH is transmitted with another pre-coding vector, which e.g. is orthogonal to the primary pre-coding vector. According to an alternative example architecture the pilots are non-precoded and the pre-coding is only applied to the data related channels. Note that 3GPP is considering an architecture based on pre-coded
30 pilots for closed loop transmit diversity. One of the main benefits with an architecture based on pre-coded DPCCH pilots is that the pre-coding vector that the UE has applied does not need be known by the network. This is because channel estimates used for demodulation can be on the pre-coded DPCCH pilot that is pre-coded in the same way as the data channels.

For closed loop transmit diversity and UL MIMO, it is important that the reception quality of the physical channel carrying the pre-coding information can be maintained at a reasonable level. It is also desirable that the UE does not
5 update its pre-coding vector too frequently, if this is not necessary, because frequent updates may cause excessive interference levels in surrounding cells as well as harm the user performance and RoT utilization efficiency at a NodeB controlling the pre-coding vector generation. Furthermore, too frequent updates of the applied pre-coding vectors will make it harder for the inner loop power
10 control (ILPC) loop to adapt to the effective pre-coded channel, which in general will exhibit larger variations than a raw radio channel if a "random" pre-coder is applied.

Thus there is a desire for schemes that help to avoid harmful situations relating
15 to pre-coding vector updates in communication systems applying closed loop multi-antenna transmission techniques such as closed loop uplink transmit diversity and uplink MIMO.

SUMMARY

20 It is an object to provide methods and apparatuses that allow for improved control in connection with uplink multi-antenna transmissions.

The above stated object is achieved by means of methods, and apparatuses according to the independent claims.

25

A first embodiment provides a method for use in a user equipment configured for multi-antenna transmissions in a telecommunication system. The method comprises a step of receiving, in a downlink channel, pre-coding vector information indicating a pre-coding vector for uplink transmission. The method
30 also comprises a step of determining whether the pre-coding vector indicated by the received pre-coding vector information is reliable or unreliable. Furthermore, according to the method, the pre-coding vector indicated by the received pre-coding vector information is applied for uplink transmission only if the pre-coding vector is determined to be reliable. If the pre-coding vector indicated by the

received pre-coding vector information is determined to be unreliable a pre-determined pre-coding vector is applied according to the method.

5 A second embodiment provides a method for use in a base station for controlling user equipments configured for multi-antenna transmissions in a telecommunication system. The method comprises a step of transmitting, on a downlink channel to a user equipment, first pre-coding vector information indicating a first pre-coding vector for uplink transmission and subsequently transmitting, on the downlink channel, second pre-coding vector information
10 indicating a second pre-coding vector for uplink transmission. The method also comprises a step of detecting whether reception quality of the downlink channel is insufficient by monitoring a relative phase difference between a first pilot signal received from the user equipment during a first time interval associated with the first pre-coding vector information and a second pilot signal received
15 from the user equipment during a second time interval associated with the second pre-coding vector information.

A third embodiment provides a user equipment configured for multi-antenna transmissions in a telecommunication system. The user equipment comprises a
20 transceiver circuit and a processing circuit. The processing circuit is configured to receive pre-coding vector information transmitted in a downlink channel, where the pre-coding vector information indicates a pre-coding vector for uplink transmission. The processing circuit is also configured to determine whether the pre-coding vector indicated by the received pre-coding vector information is
25 reliable or unreliable. In addition the processing circuit is configured to apply the pre-coding vector indicated by the received pre-coding vector information for uplink transmission only if the pre-coding vector is determined to be reliable and to apply a pre-determined pre-coding vector when the pre-coding vector indicated by the received pre-coding vector information is determined to be
30 unreliable.

A fourth embodiment provides a base station for controlling user equipments configured for multi-antenna transmissions in a telecommunication system. The base station is configured to transmit, on a downlink channel to a user

equipment, first pre-coding vector information indicating a first pre-coding vector for uplink transmission and subsequently transmit, on the downlink channel, second pre-coding vector information indicating a second pre-coding vector for uplink transmission. The base station is also configured to detect whether
5 reception quality of the downlink channel is insufficient by monitoring a relative phase difference between a first pilot signal received from the user equipment during a first time interval associated with the first pre-coding vector information and a second pilot signal received from the user equipment during a second time interval associated with the second pre-coding vector information.

10

An advantage of some of the embodiments of this disclosure is that smaller variations in intra and inter-cell interference levels may be achieved. This is desirable to ensure efficient RoT utilization. Some embodiments of this disclosure specify a method, advantageously known by both a UE and a base
15 station, which determines which pre-coding vector(s) the UE applies when it cannot decode the pre-coding vector information with a sufficient reliability. By ensuring that the UE does not apply the decoded pre-coding vector if the estimated reception quality of the physical channel carrying the pre-coding information is below a certain quality situations where the UE direct the beam
20 inappropriately and cause undesirably high interference in neighboring cells may be avoided. Thus the performance of the UE may be improved.

A further advantage of some of the embodiments of this disclosure is that reduced changes in the effective channel can be achieved, i.e. the combined
25 changes of the radio channel, antenna gains and the pre-coder may be reduced. This may in turn be beneficial for the inner loop power control.

Another advantage of some of the embodiments of this disclosure it that the base station is enabled to detect that the reception quality of the physical
30 channel carrying the pre-coding vector information is viewed as unreliable by the UE.

Further advantages and features of embodiments of this disclosure will become apparent when reading the following detailed description in conjunction with the drawings.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic block diagram illustrating an exemplary transmit diversity scheme.

Fig. 2 is a schematic block diagram illustrating mapping of antenna ports to physical antennas.

10 Fig. 3 is a schematic block diagram illustrating an embodiment of a user equipment architecture supporting closed loop beamforming with non-precoded pilots.

Fig. 4 is a schematic block diagram illustrating an alternative embodiment of a user equipment architecture supporting closed loop beamforming with precoded
15 pilots.

Fig. 5 is a flow diagram illustrating an embodiment of a method for use in a user equipment for controlling uplink multi-antenna transmissions.

Fig. 6 is a flow diagram illustrating an embodiment of a method for use in a base station controlling user equipments configured for multi-antenna transmissions.

20 Fig. 7 is a schematic block diagram of an exemplary embodiment of a user equipment.

Fig. 8 is a schematic block diagram of an exemplary embodiment of a NodeB.

DETAILED DESCRIPTION

25 The embodiments of this disclosure will now be described more fully hereinafter with reference to the accompanying drawings, in which different example embodiments are shown. These example embodiments are provided so that this disclosure will be thorough and complete and not for purposes of limitation. In the drawings, like reference signs refer to like elements.

30

The inventors have realized that there are good reasons for ensuring that the UE does not apply the decoded pre-coding vector if the estimated reception quality of the physical channel carrying the pre-coding information is below a certain quality. Embodiments which will be described in further detail below

provide methods and apparatuses enabling a UE to apply a pre-determined pre-coding vector in situations where estimated reception quality of pre-coding information sent from the network is judged unreliable by the UE. The quality estimate could be based on the downlink quality of the physical channel carrying the pre-coding information or of other physical downlink channels than the physical channel carrying the pre-coding information. In one embodiment, the UE always utilizes a fixed, pre-determined pre-coding matrix or vector if the feedback quality is considered as unreliable. In another embodiment the UE applies the most recently received pre-coding vector(s) associated with a sufficient reception quality in periods where the estimated downlink quality is judged as being unreliable. Although most of the embodiments described in detail below are described in a context of closed loop uplink transmit diversity embodiments of this disclosure are applicable to both closed loop uplink transmit diversity schemes and uplink MIMO.

15

Fig. 1 is a schematic block diagram illustrating an exemplary transmit diversity system in which different embodiments of this disclosure may be implemented. Fig. 1 shows a transmitting unit, such as a UE, comprising physical transmit antennas a_1, a_2, \dots, a_N . An input signal $s(t)$ to be transmitted is mapped to N antenna ports via complex weights w_1, w_2, \dots, w_N prior to transmission from a respective physical antenna. Note that in the example illustrated in Fig. 1 each antenna port corresponds to a physical transmit antenna. Fig. 1 also illustrates a receiving unit 12, such as a NodeB, comprising receive antennas b_1, \dots, b_M . The composite channel between the transmitting unit and the receiving unit comprises wireless channels h_{ij} , where $i=1, \dots, N$ and $j=1, \dots, M$, between the different transmit antennas a_1, a_2, \dots, a_N and receive antennas b_1, \dots, b_M as illustrated in Fig. 1.

Fig. 2 is a schematic block diagram illustrating an alternative system in which different embodiments of this disclosure may be implemented. Fig. 2 discloses a transmitting unit 21 such as a UE, comprising physical transmit antennas a_1, a_2, \dots, a_N and a receiving unit 12, such as a NodeB, comprising receive antennas b_1, \dots, b_M . The composite channel between the transmitting unit and the receiving unit comprising wireless channels h_{ij} , where $i=1, \dots, N$ and $j=1, \dots, M$, is also

illustrated in Fig. 2. In contrast to the transmitting unit 11 of Fig. 1, the transmitting unit 21 of Fig. 2 comprises K antenna ports which are mapped to the N physical antennas as illustrated in Fig. 2.

5 Figs. 3 and 4 illustrate two possible UE architectures that can support closed loop beamforming. Both Fig. 3 and Fig. 4 illustrate that the UE comprises two physical antennas 23 and 24. Fig. 3 illustrates a structure based on non-precoded (DPCCH) pilots 33 and 34. In the example of Fig. 3 the pre-coding is only applied to the data related channels. Fig. 4 shows a UE architecture
10 with pre-coded pilots. In this structure one of the DPCCH pilots and all of the other physical channels are transmitted using a certain, so-called primary, pre-coding vector and the other DPCCH pilot is transmitted with another, e.g. orthogonal pre-coding vector. As mentioned above, one of the main benefits with an architecture based on pre-coded DPCCH pilots is that the pre-coding
15 vector that the UE has applied does not need be known by the network. This is because the channel estimates used for demodulation can be on the pre-coded DPCCH pilot that is pre-coded in the same way as the data channels; see P-DPCCH in Fig. 4.

20 Fig. 5 is a flow diagram illustrating an example embodiment of a method for use in a UE 61 configured for multi-antenna transmissions. The method comprises a step 62 of receiving pre-coding vector information indicating a pre-coding vector for uplink transmission. The pre-coding vector information is received in a downlink channel. In a step 62 the UE determines whether the pre-coding vector
25 indicated by the received pre-coding vector information is reliable or unreliable, in other words whether the received pre-coding vector information is reliable such that the pre-coding vector which the UE perceives is indicated by the received pre-coding vector information is the same pre-coding vector that the sender of the pre-coding vector information intended to indicate by means of the
30 pre-coding vector information. If the pre-coding vector is determined to be reliable, the UE applies the pre-coding vector indicated by the received pre-coding vector information for uplink transmission in a step 64. If the pre-coding vector indicated by the received pre-coding vector information is determined to

be unreliable, a pre-determined pre-coding vector is applied according to a step 66.

5 In an example embodiment the UE 61 applies a pre-coder W signaled by the network if the estimated downlink reception quality Q_{est} associated with the pre-coding information is judged as sufficient. For example, if the estimated quality is below a certain quality threshold Q^* then the UE does not apply the pre-coder W . Instead, the UE applies a pre-determined pre-coder W_0 . As long as the estimated quality of the downlink channel and thus the reliability of the pre-coding vector information is judged as being sufficient, in other words Q_{est} is 10 larger or equal than the threshold Q^* , the UE applies the pre-coder W signaled by the network.

15 In an alternative embodiment the UE applies the most recently received pre-coder that has been judged as being reliable. To exemplify, if the UE received pre-coder W_{t-1} at time-instance $t-1$ and the quality of the physical channel used to signal the pre-coder was judged as being sufficient and the quality of the downlink channel is judged as being unreliable at time t , then the UE will continue to use the pre-coder W_{t-1} even though a new, other pre-coder has 20 been decoded. This pre-coder could be applied for a fixed time-duration or until the quality of the received pre-coding information is judged as being reliable again. A benefit of this alternative embodiment is that if the downlink quality associated with the physical channel used by the UE to judge whether the pre-coding information is reliable varies around the quality threshold Q^* a flip-flop 25 UE behavior in terms of the applied pre-coder can be avoided.

An advantage common for both embodiments mentioned above is that the UE utilize a pre-determined pre-coding vector in case the pre-coding vector indicated by the pre-coding vector information is determined to be unreliable. 30 The pre-determined pre-coding vector could be applied for a fixed time-duration or until the quality of subsequently received pre-coding vector information is judged as being reliable. Thus if the pre-coding vector information sent on the downlink is judged as being unreliable for a "long" time duration the UE will utilize a constant pre-coding vector during this time-period. This will result in:

- Reduced changes in the effective channel, i.e. the combined changes of the radio channel, antenna gains, and the pre-coder. This may in turn be beneficial for the inner loop power control loop.
- Smaller variations in intra and inter-cell interference levels. This is desirable to ensure efficient RoT utilization.

Fig. 6 is a flow diagram illustrating a method for use in a base station 71, e.g. a NodeB, for controlling UEs configured for multi-antenna transmissions. According to a step 72, the base station 71 transmits pre-coding vector information to the UE on a downlink channel. In a step 73 the base station 71 detects whether reception quality of the downlink channel is insufficient by monitoring a relative phase difference between pilot signals received from the UE. To be more concrete, the base station 71 could use the two most recently transmitted pre-coding information commands and the pilots received during the two associated slots (or subframes if the UE update its pre-coding vector on a per subframe basis). By comparing the received pilots during the two time intervals (slots or subframes), the base station 71 can estimate how large the change in relative phase associated with the DPCCHs is and compare this to the relative phase difference of the pre-coding vectors that the base station 71 transmitted. If there is a difference in phase between the pre-coding vectors transmitted by the base station and the base station does not detect any phase difference in the received DPCCHs then this can be used as an indication that the received pre-coding information at the UE is considered as unreliable. If the base station knows that the UE will use a predetermined fixed pre-coding vector if the UE determines that the received pre-coding vector information is reliable, it is possible for the base station to detect that the received pre-coding vector information is considered unreliable by the UE in further ways. If there is no relative phase difference between the pre-coding vectors transmitted by the base station and a phase difference is detected between the received pilots this is also an indication that the received pre-coding information is considered unreliable by the UE since this indicates that the UE used the pre-determined fixed pre-coding vector for uplink transmission.

It may be beneficial for the base station to be aware of when the UE considers the pre-coding vector information unreliable. The base station may be able to increase the transmission power when transmitting the pre-coding vector information in order to increase the reliability. If the base station is unable to increase the transmission power when the UE considers the pre-coding vector information to be unreliable, the base station may instead choose to inactivate the uplink multi-antenna transmission. Closed loop transmit diversity (CLTD) may be inactivated by the base station by means of a High Speed Shared Control Channel (HS-SCCH) order to thereby save power. Furthermore, decoding of uplink transmissions at the base station may be improved if the base station knows which pre-coding vector the UE has used for the uplink transmission.

Fig. 7 illustrates an exemplary UE 61. The UE 61 comprises a transceiver circuit 91 and a processing circuit 90, which may be configured to carry out a method for use in a UE according to any of the embodiments described above. The UE 61 also comprises a plurality of antennas a_1, \dots, a_N to be able to perform uplink transmissions according to a multi-antenna transmission technique such as closed loop uplink transmit diversity or uplink MIMO. The transceiver circuit 91 comprises any type of wireless transceiver, such as a WCDMA transceiver, Long Term Evolution (LTE) transceiver, or Wireless Local Area Network (WLAN) transceiver. The processing circuit comprises one or more processors, hardware, firmware, or a combination thereof. According to an exemplary embodiment, the processing circuit 90 includes a pre-coder for pre-coding transmitted signals. The processing circuit 90 is configured to receive, from a serving NodeB, a pre-coding vector for a specified transmission interval and configured to determine a reliability of the pre-coding vector. If the processing circuit 90 determines that the pre-coding vector is reliable, it pre-codes a transmit signal for the specified transmission interval using the received pre-coding vector. If the processing circuit 90 determines that the pre-coding vector is not reliable, it pre-codes a transmit signal for the specified transmission interval using a default pre-coding vector or a pre-coding vector for a previous transmission interval that is deemed to be reliable. In some embodiments, the processing circuit 90 determines the reliability of the pre-coding vector based on a quality of a downlink channel. The processing circuit 90 may e.g. be

configured to execute software instructions of one or several computer program products to implement different modules, such as exemplary modules 93 and 94 illustrated in Fig. 7. The module 93 is a physical channel quality estimator which is configured to estimate reception quality of a downlink channel to determine if the pre-coding vector indicated by the received pre-coding vector information is reliable or unreliable. The module 94 is a pre-coding vector processor which is configured to apply the pre-coding vector indicated by the pre-coding vector or a predetermined pre-coding vector for uplink transmission depending on whether the pre-coding vector indicated by the pre-coding vector information is determined to be reliable or unreliable.

Fig. 8 illustrates an exemplary embodiment of a base station 71. The base station 71 is a NodeB, which may be configured to interact with the UE 61 illustrated in Fig. 7. The NodeB 71 comprises transceiver circuitry 96 and processing circuitry 95, which e.g. may be configured to carry out the method illustrated in Fig. 6. The NodeB 71 also comprises antennas b_1, \dots, b_N . The transceiver circuitry 96 is configured to transmit pre-coding vector information indicating pre-coding vectors for uplink transmission to UEs 61. The processing circuitry 95 comprises one or more processors, hardware, firmware, or a combination thereof. According to an exemplary embodiment, the processing circuitry 95 is configured to detect whether reception quality of a downlink channel is insufficient by monitoring a relative phase difference between received pilots according to the method step 73 illustrated in Fig. 6 and described above. The processing circuitry 95 may e.g. be configured to execute software instructions of one or several computer program products to implement different modules, such as exemplary modules 98 and 99 illustrated in Fig. 8. The module 98 is a pre-coding vector information generator which is configured to generate the pre-coding vector information to be transmitted to one or several UEs to recommend pre-coding vector(s) for uplink transmission. The module 99 is a module for downlink quality detection which is configured to detect indications that the downlink quality associated with the pre-coding vector information is viewed as unreliable by the UE(s).

In the drawings and specification, there have been disclosed typical embodiments and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

5

CLAIMS

1. A method for use in a user equipment (61) configured for multi-
antenna transmissions in a telecommunication system, the method comprising
5 receiving (62), in a downlink channel, pre-coding vector information
indicating a pre-coding vector for uplink transmission;
determining (62) whether the pre-coding vector indicated by the
received pre-coding vector information is reliable or unreliable;
applying (64) the pre-coding vector indicated by the received pre-
10 coding vector information for uplink transmission only if the pre-coding vector is
determined to be reliable; and
applying (66) a pre-determined pre-coding vector when the pre-
coding vector indicated by the received pre-coding vector information is
determined to be unreliable.
- 15 2. The method according to claim 1, wherein said pre-determined pre-
coding vector is a pre-determined fixed pre-coding vector.
3. The method according to claim 1, wherein said pre-determined pre-
20 coding vector is the most recently received pre-coding vector which has been
judged as being reliable.
4. The method according to any one of claims 1-3, wherein said pre-
determined pre-coding vector is applied for uplink transmission during a fixed
25 time-duration.
5. The method according to any one of claims 1-3, wherein said pre-
determined pre-coding vector is applied until the quality of subsequently
received pre-coding vector information is determined to be reliable.
- 30 6. The method according to any of claims 1-5, wherein the pre-coding
vector indicated by the received pre-coding vector information is determined to
be unreliable if an estimated quality of the downlink channel used to signal the
pre-coding vector information is below a threshold.

7. A method for use in a base station (71) for controlling user equipments (61) configured for multi-antenna transmissions in a telecommunication system, the method comprising
- 5 transmitting (72), on a downlink channel to a user equipment (61), first pre-coding vector information indicating a first pre-coding vector for uplink transmission and subsequently transmitting, on said downlink channel, second pre-coding vector information indicating a second pre-coding vector for uplink transmission; and
- 10 detecting (73) whether reception quality of said downlink channel is insufficient by monitoring a relative phase difference between a first pilot signal (33, 34) received from the user equipment during a first time interval associated with the first pre-coding vector information and a second pilot signal (33, 34) received from the user equipment during a second time interval associated with
- 15 the second pre-coding vector information.
8. The method according to claim 7, wherein an indication of insufficient reception quality is detected if there is a relative phase difference between said first and second pre-coding vectors and no phase difference is
- 20 detected between the received first and second pilot signals (33, 34).
9. The method according to claim 7 or 8, wherein the first and second time intervals are time slots.
- 25 10. The method according to claim 7 or 8, wherein the first and second time intervals are subframes.
11. A user equipment (61) configured for multi-antenna transmissions in a telecommunication system, the user equipment (61) comprising a
- 30 transceiver circuit (91) and a processing circuit (90), wherein the processing circuit (90) is configured to
- receive, in a downlink channel, pre-coding vector information indicating a pre-coding vector for uplink transmission;

determine whether the pre-coding vector indicated by the received pre-coding vector information is reliable or unreliable;

5 apply the pre-coding vector indicated by the received pre-coding vector information for uplink transmission only if the pre-coding vector is determined to be reliable; and

apply a pre-determined pre-coding vector when the pre-coding vector indicated by the received pre-coding vector information is determined to be unreliable.

10 12. The user equipment (61) according to claim 11, wherein said pre-determined pre-coding vector is a pre-determined fixed pre-coding vector.

13. The user equipment (61) according to claim 11, wherein said pre-determined pre-coding vector is the most recently received pre-coding vector
15 which the processing circuit (90) has judged as being reliable.

14. The user equipment (61) according to any one of claims 11-13, wherein the processing circuit (90) is configured to apply said pre-determined pre-coding vector for uplink transmission during a fixed time-duration.

20

15. The user equipment (61) according to any one of claims 11-13, wherein the processing circuit (90) is configured to apply said pre-determined pre-coding vector until the quality of subsequently received pre-coding vector information is determined to be reliable.

25

16. The user equipment (61) according to any of claims 11-15, wherein the processing circuit (90) is configured to determine that the pre-coding vector indicated by the received pre-coding vector information is unreliable if an estimated quality of the downlink channel used to signal the pre-coding vector
30 information is below a threshold.

17. A base station (71) for controlling user equipments (61) configured for multi-antenna transmissions in a telecommunication system, wherein the base station (71) is configured to

transmit, on a downlink channel to a user equipment (61), first pre-coding vector information indicating a first pre-coding vector for uplink transmission and subsequently transmit, on said downlink channel, second pre-coding vector information indicating a second pre-coding vector for uplink
5 transmission; and

detect whether reception quality of said downlink channel is insufficient by monitoring a relative phase difference between a first pilot signal (33, 34) received from the user equipment during a first time interval associated with the first pre-coding vector information and a second pilot signal (33, 34)
10 received from the user equipment during a second time interval associated with the second pre-coding vector information.

18. The base station (71) according to claim 17, wherein the base station is configured to detect an indication of insufficient reception quality if
15 there is a relative phase difference between said first and second pre-coding vectors and no phase difference is detected between the received first and second pilot signals (33, 34).

19. The base station according to claim 17 or 18, wherein the first and
20 second time intervals are time slots.

20. The base station according to claim 17 or 18, wherein the first and second time intervals are subframes.

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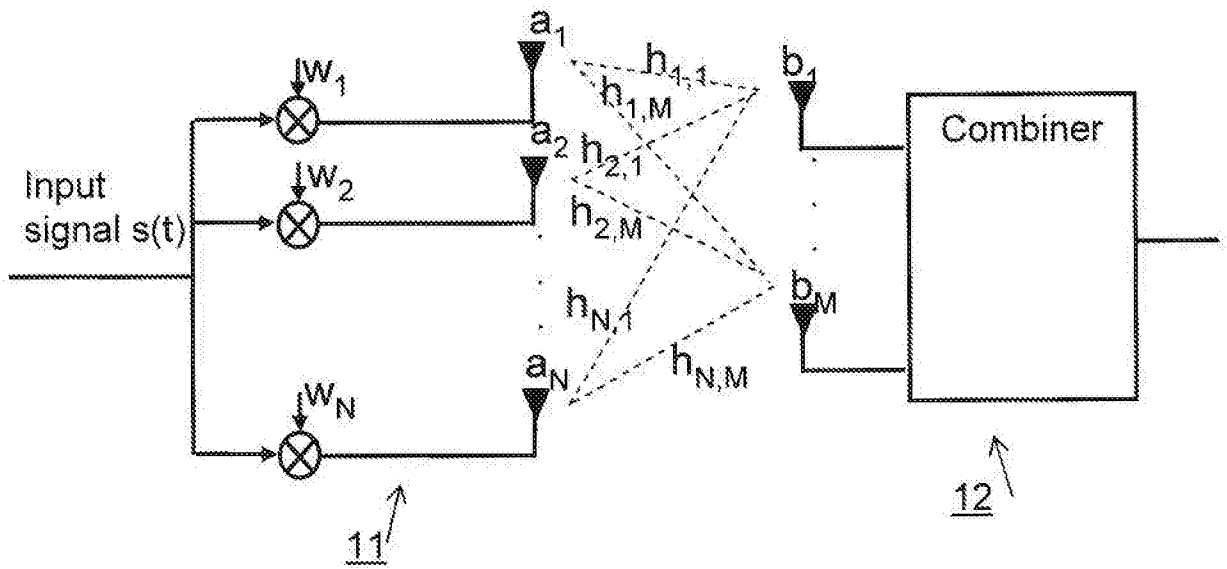


Fig. 1

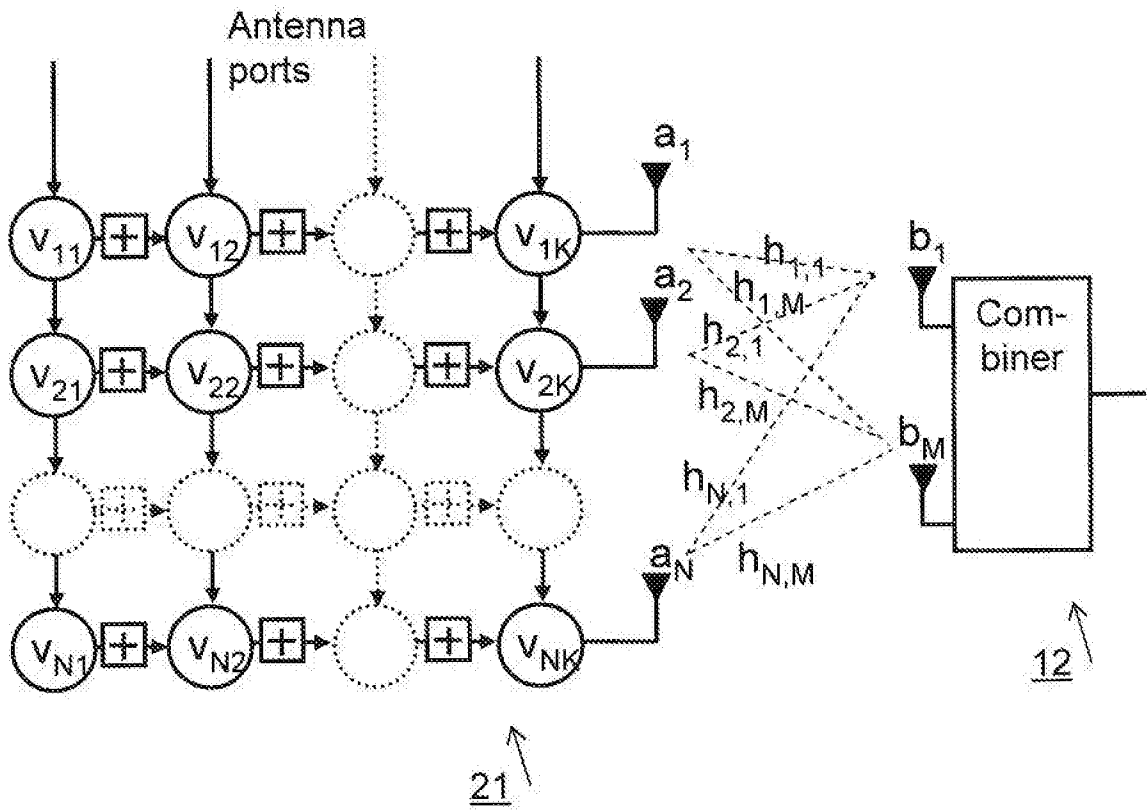


Fig. 2

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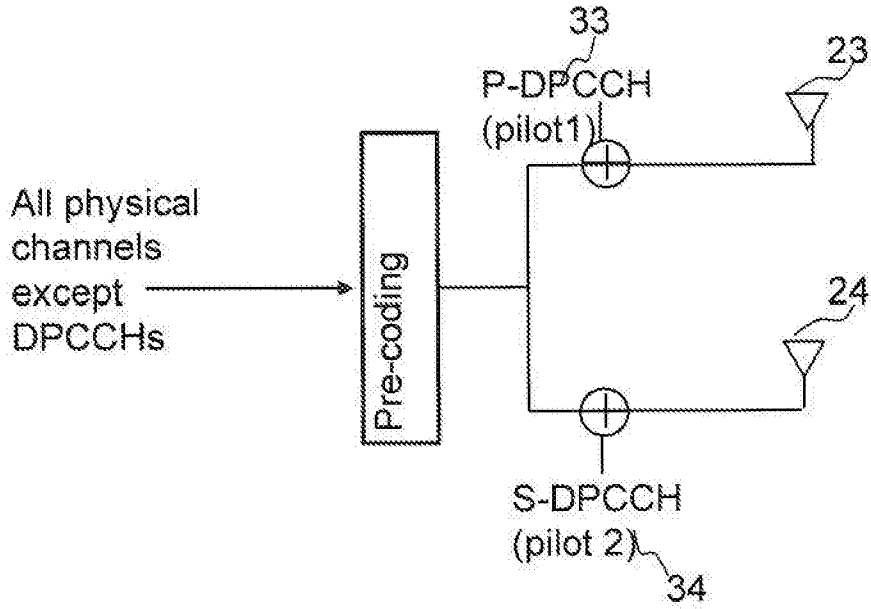


Fig. 3

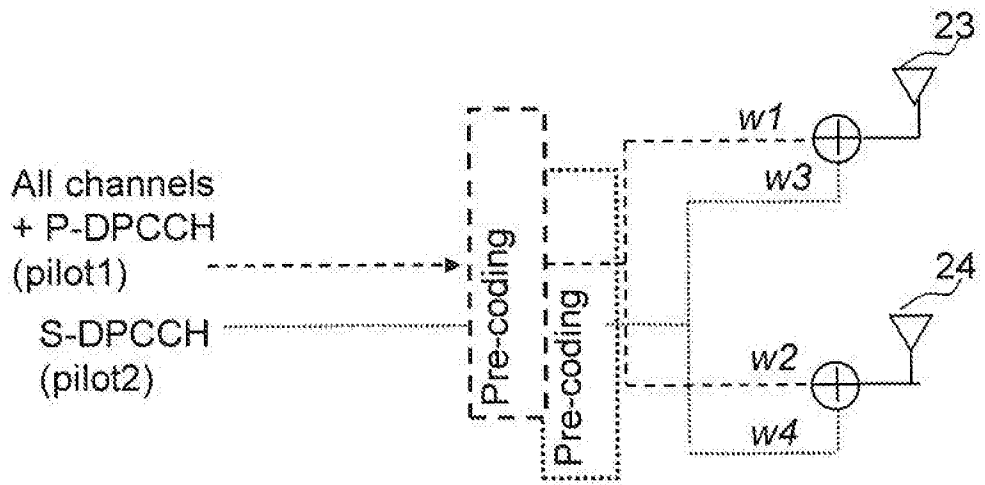


Fig. 4

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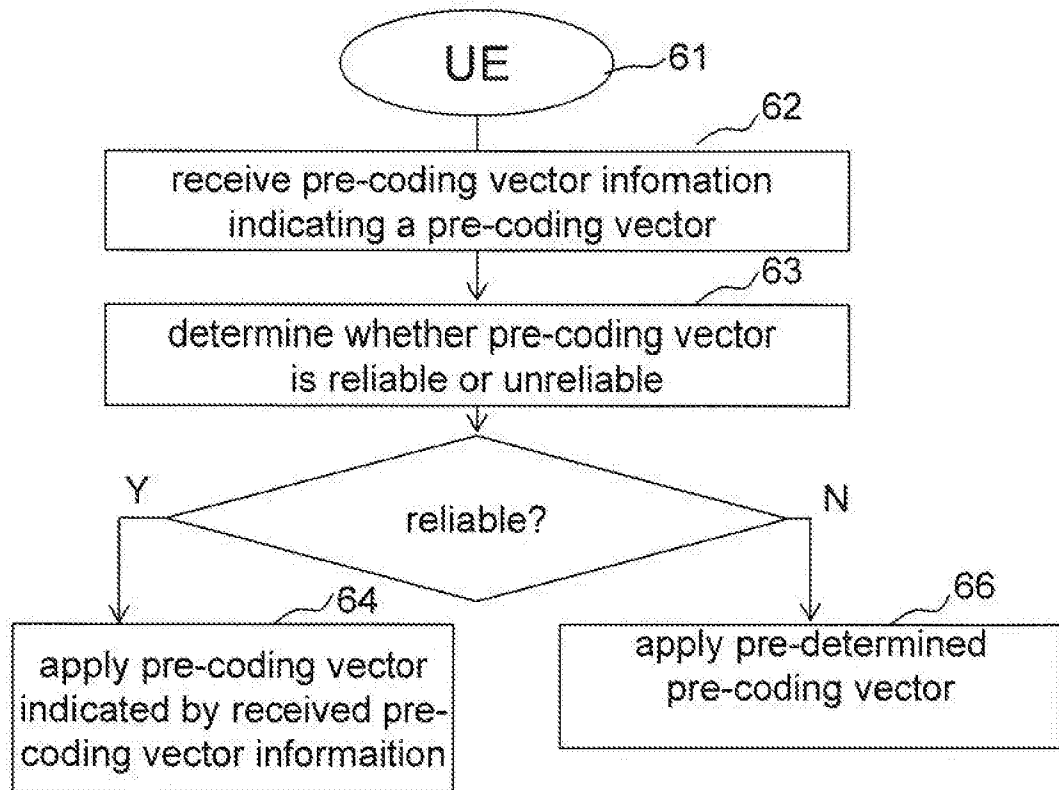


Fig. 5

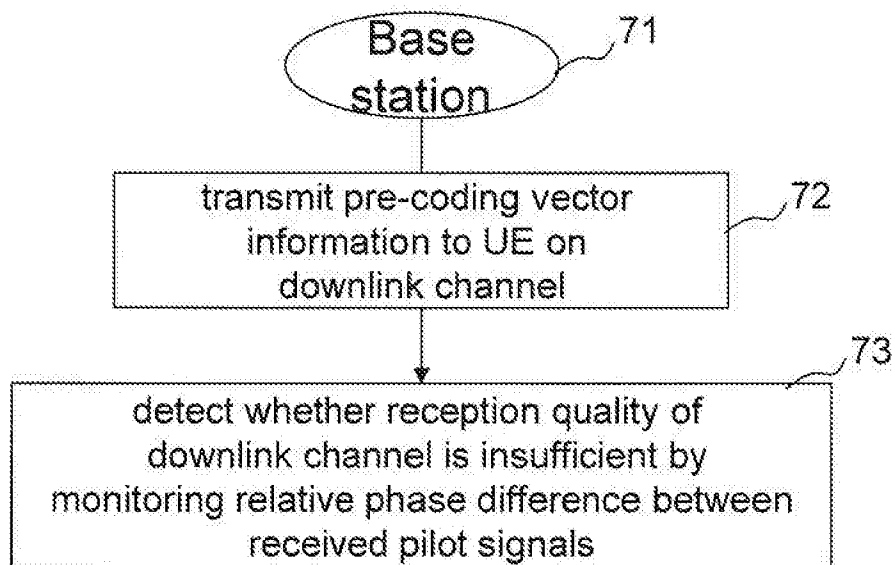


Fig. 6

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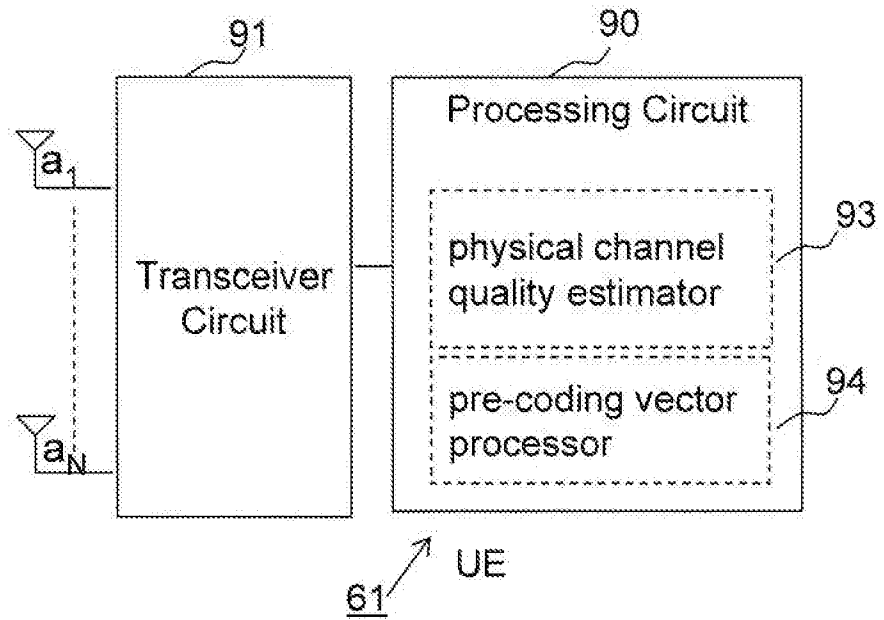


Fig. 7

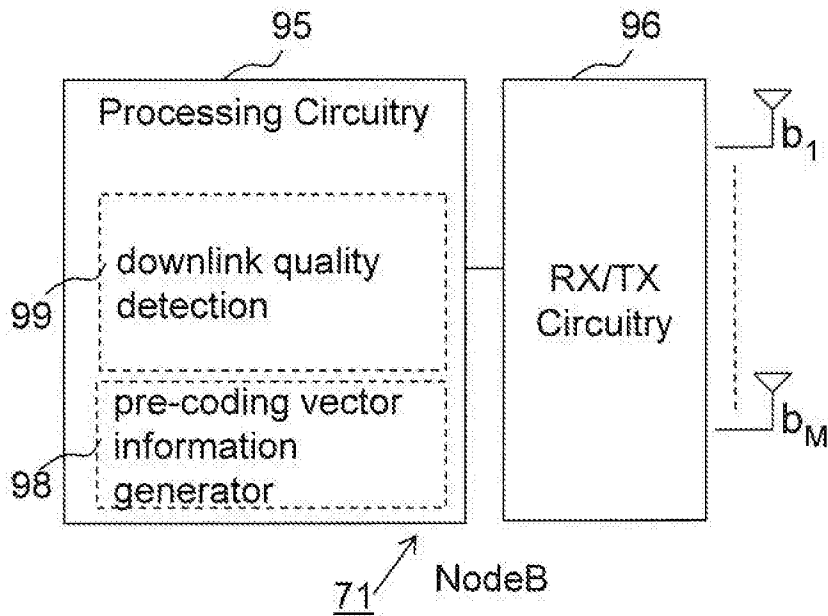


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No PCT/SE2012/050144

A. CLASSIFICATION OF SUBJECT MATTER
 INV. H04B7/06
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 2 169 845 A1 (NTT DOCOMO INC [JP]) 31 March 2010 (2010-03-31) paragraph [0013] - paragraph [0014] paragraph [0019] - paragraph [0020] paragraph [0025] - paragraph [0032] paragraph [0049] - paragraph [0055] -----	1-6, 11-16 7-10, 17-20
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Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search

13 April 2012

Date of mailing of the international search report

23/04/2012

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/SE2012/050144

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