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- (71) **Applicant:** ALCATEL LUCENT [FR/FR]; 148/152 route de la Reine, 92100 Boulogne-Billancourt (FR).
- (72) **Inventors:** LUO, Qinglin; 388# Ningqiao Road, Pudong Jinqiao, Shanghai 201206 (CN). ZHANG, Min; 62 Mus-

tang Way, Swindon Wiltshire SN55DY (GB). YANG, Tao; 388# Ningqiao Road, Pudong Jinqiao, Shanghai 201206 (CN).

- (74) **Agent:** BERTHIER, Karine; Alcatel-Lucent International, 148/152 route de la Reine, 92100 Boulogne-Billancourt (FR).

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- (54) **Title:** METHOD OF IMPROVING CHANNEL QUALITY FEEDBACK

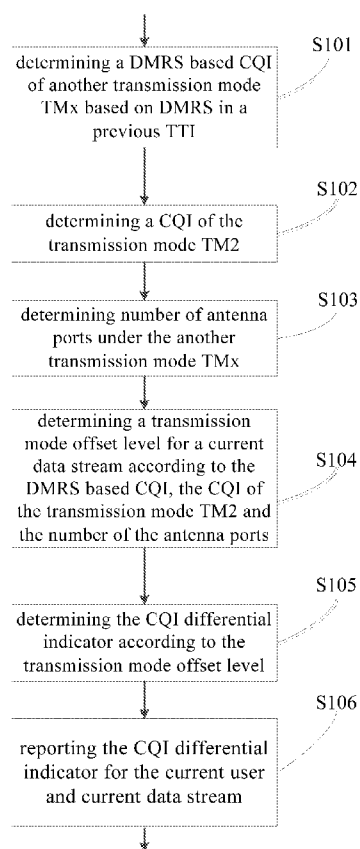


Fig.1

(57) **Abstract:** The present invention provides a method of improving channel quality feedback. According to an embodiment of the present invention, it is proposed a method, in a user equipment, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method comprising: transmitting a channel quality indicator of a transmission mode TM2 and a differential indicator to an eNB, the differential indicator indicating a relative gain of another transmission mode relative to the transmission mode TM2. Through the present invention, an accurate CQI feedback is realized for a 3D MIMO TDD system. Meanwhile, the link adaptation for the TDD system according to the present invention does not rely on the open-loop link adaptation mechanism.



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Method of Improving Channel Quality Feedback

Field of the invention

The present disclosure relates to mobile communication technology, and particularly to a method of improving channel quality feedback.

Background of the invention

3D MIMO promises to increase the quality of transmission by pointing the radio beam in a 3-dimensional way to a user equipment (UE) so as to focus the power more on the intended UE and avoid interference to other UEs. 3GPP RAN1 has decided to continue the study of full-dimensional MIMO in LTE Release 13 discussion, targeting at identifying the need for supporting full-dimensional MIMO scheme with 8/16/64 TX ports. Candidate solutions and the related requirements for UE channel state information (CSI) feedback and high-level signaling enhancement need to be proposed and evaluated. The performance of the solutions should be achieved with minimum cost of system/standardization complexity.

For a TDD system, the channel reciprocity can be exploited for realizing the high potential of the 3D MIMO. The channel state information (CSI) is obtained from an uplink channel sounding signal, and no CSI quantization is needed thus the performance loss due to quantization error can be avoided. Simulation results show that TDD 3D MIMO, which is based on channel reciprocity, (non-codebook based precoding) can generally outperform codebook based 3D MIMO by assuming ideal channel quality indicator (CQI) feedback. But it was found that since the TDD CQI (non-PMI based CQI) in LTE/LTE-A is based on the assumption of a TM2 transmission, the CQI feedback from a TDD UE has to be corrected with a factor determined by the eNB

according to its estimation of the relative gain of TMx over TM2, where the 'TMx' means TM7, TM8, TM9, or TM10, and any other transmission modes developed by 3GPP in future.

However, with the increasing of the number of antennas and especially the introduction of the complex 2D antenna array in 3D MIMO, each UE has more opportunity to be allocated with multiple layers on one hand, and on the other hand high order multi-user transmission will be supported for more efficient use of the radio resources. All these features lead to a fully dynamic gain gap between TMx and TM2 depending on UE's receiving capability, thus it becomes very difficult to estimate/compensate such a gap at the eNB side without any extra UE feedback.

There is no disclosed approach yet on how to enhance the design and feedback of non-codebook based CQI (TDD CQI) for 3D MIMO. In previous 3D MIMO evaluations, the ideal TDD CQI which is calculated by assuming knowing the downlink precoder at the UE side is assumed. This is unrealistic for practical systems.

In codebook based CQI study, researchers have mentioned that except the codebook based CQI solution, it is also possible to design a non-codebook based CQI solution which means to let the UE to determine the CQI based on DMRS measurement. The obvious drawback of such an approach is that the equivalent channel obtained from DMRS measurement represents the equivalent channel for the previous TTI. It may become outdated for the next TTI with scheduling immediately changing.

Summary of the invention

In this disclosure, it is proposed that a CQI correction factor would be feedback to improve the current TM2 non-codebook based feedback scheme. Herein, multiple alternative methods are proposed to measure and feedback the additional factor for correcting the traditional CQI for

a non-codebook based 3D MIMO system.

According to a first aspect of the present invention, it is proposed a method, in a user equipment, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method comprising:
5 transmitting a channel quality indicator of a transmission mode TM2 and a differential indicator to an eNB, the differential indicator indicating a relative gain of another transmission mode relative to the transmission mode TM2.

Advantageously, the differential indicator is determined by
10 comparing DMRS based channel quality of the another transmission mode with channel quality of the transmission mode TM2.

Advantageously, determining a DMRS based channel quality indicator of the another transmission mode based on DMRS in a previous TTI; determining a channel quality indicator of the
15 transmission mode TM2; determining number of antenna ports under the another transmission mode; determining a transmission mode offset level according to the DMRS based channel quality indicator, the channel quality indicator of the transmission mode TM2 and the number of the antenna ports; and determining the differential indicator
20 according to the transmission mode offset level.

Advantageously, the another transmission mode at least includes transmission mode TM7, TM8, TM9 and TM10.

According to a second aspect of the present invention, it is proposed a method, in a user equipment, of improving channel quality
25 feedback in a non-codebook based 3D MIMO system, the method comprising: transmitting a channel quality indicator of a transmission mode TM2 and at least one differential indicator to an eNB, wherein each differential indicator is used to indicate a relative receiving gain for a data stream configured for a the user equipment, respectively.

Advantageously, determining SINR for the transmission mode
30 TM2; determining number of antenna ports under another transmission

mode; determining the relative receiving gain as a quotient of an eigen power of an equivalent channel matrix under the another transmission mode for the data stream and a normalization factor; determining a offset level of a channel quality indicator of a receiver according to the SINR, the number of the antenna ports and the relative receiving gain; and determining the differential indicator according to the offset level.

Advantageously, the normalization factor is determined according to a channel autocorrelation matrix under the transmission mode TM2, a receiver matrix and its transport matrix.

According to a third aspect of the present invention, it is proposed a method, in an eNB, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method comprising: receiving a channel quality indicator of a transmission mode TM2 and a differential indicator from a user equipment, wherein the differential indicator is used to indicate a relative gain of another transmission mode relative to the transmission mode TM2 or a relative receiving gain for a data stream configured for the user equipment; determining SINR for the transmission mode TM2 according to the channel quality indicator of the transmission mode TM2; determining an ideal SINR for the another transmission mode according to number of the antenna ports under the another transmission mode and the SINR for the transmission mode TM2; determining an ideal channel quality indicator of the another transmission mode according to the ideal SINR; correcting the ideal channel quality indicator with the differential indicator to determine a channel quality indicator the of the another transmission mode.

According to a fourth aspect of the present invention, it is proposed a method, in a user equipment, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method comprising: transmitting a channel quality indicator of a transmission mode TM2 and a first indication message to an eNB, wherein the first

indication message is used to indicate a left autocorrelation receiver matrix, and the left autocorrelation receiver matrix is a product of a receiver matrix and its transport matrix.

Advantageously, the first indication message includes: a receiver matrix indicator and at least one differential indicator, wherein each differential indicator is used to indicate a relative eigen power for a data stream configured for the user equipment, respectively.

Advantageously, determining number of antenna ports under another transmission mode; determining the relative eigen power as a quotient of an eigen power of a receiver matrix under the another transmission mode for the data stream and a normalization factor; determining a offset level of a channel quality indicator of a receiver according to the number of the antenna ports and the relative eigen power; and determining the differential indicator according to the offset level.

Advantageously, the normalization factor is determined according to a channel autocorrelation matrix under the transmission mode TM2, a receiver matrix and its transport matrix.

According to a fifth aspect of the present invention, it is proposed a method, in an eNB, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method comprising: receiving a channel quality indicator of a transmission mode TM2 and a first indication message from a user equipment, wherein the first indication message is used to indicate a left autocorrelation receiver matrix, and the left autocorrelation receiver matrix is a product of a receiver matrix and its transport matrix; obtaining a channel autocorrelation matrix under the transmission mode TM2 and a channel autocorrelation matrix under another transmission mode based on channel reciprocity; determining a SINR relative gain of the another transmission mode relative to the transmission mode TM2 according to the left autocorrelation receiver matrix, the channel autocorrelation

matrix under the transmission mode TM2 and the channel autocorrelation matrix under another transmission mode; determining SINR of the transmission mode TM2 according to the channel quality indicator of the transmission mode TM2; determining SINR of the another transmission mode according to the SINR relative gain and the SINR of the transmission mode TM2; and determining a channel quality indicator of the another transmission mode based on the SINR of the another transmission mode.

Multiple schemes for improving the CQI in a non-codebook based MIMO system. For example, a CQI differential can be feedback to indicate the gain difference between TMx and TM2. For example, one indicator can be feedback to help the eNB to reconstruct the CQI for TMx.

The advantages of those schemes are in that: 1) It enables accurate CQI feedback for 3D MIMO TDD systems; 2) The link adaptation of such TDD systems will no longer rely on the open-loop link adaptation mechanism which has been proved to be inefficient and difficult to converge, especially for high-order SU-MIMO or multi-user MIMO systems; 3) The eNB can predict the channel quality of next TTI. Through the present invention, the link performance will be improved and will be more stable.

In sum, the schemes according to the present invention will achieve significant gain for high order 3D TDD SU-MIMO or MU-MIMO.

Brief description of drawings

Other features, objects and advantages of the invention will become more apparent upon review of the following detailed description of non-limiting embodiments taken with reference to the drawings in which:

Figure 1 shows a flowchart of an exemplary method for deriving a

CQI differential indicator according to an embodiment of the present invention;

Figure 2 shows a flowchart of an exemplary method for deriving a CQI differential indicator according to a further embodiment of the present invention;

Figure 3 shows a flowchart of a method for improving channel quality feedback in an eNB in a non-codebook based 3D MIMO system according to one embodiment of the present invention;

Figure 4 shows a flowchart of an exemplary method for deriving a CQI differential indicator according to an embodiment of the present invention; and

Figure 5 shows a flowchart of a method for improving channel quality feedback in an eNB in a non-codebook based 3D MIMO system according to another embodiment of the present invention.

In the drawings, identical or like reference numerals denote identical or corresponding components or features throughout the different figures.

Detailed description of embodiments

In this disclosure, 3GPP specifications would be followed to define the channel quality indicator as indication of the receiving SINR before, so that the 10% BLER receiving target can be met. Herein, multiple alternative schemes are proposed in a non-codebook based 3D MIMO system to improve the measurement and the report of the CQIs.

Before discussing the schemes in detail, the LTE-A downlink would be modeled into the following equation:

$$\mathbf{Y} = \mathbf{G}(\mathbf{H}\mathbf{W}\mathbf{S} + \mathbf{I}_{\text{oc}} + \mathbf{N});$$

where $\mathbf{H}$ represents the MIMO channel, $\mathbf{W}$ represents the TMx precoder, $\mathbf{S}$ represents the signals, $\mathbf{I}_{\text{oc}}$ represents the other cell interference, $\mathbf{N}$ represents the noise, $\mathbf{G}$ represents the user receiver, and $\mathbf{Y}$ represents received signals.

In this invention, the TMx denotes TM7, TM8, TM9 and TM10 following the definition of 3GPP TS36.213, and other potential new transmission modes that would be defined in future.

Without loss of generality, the system is assumed as a multi-user MIMO system, and the single-user MIMO is treated as a special case of multi-user MIMO. If user 1 is taken among the K users as the representative user for analysis (the following description would be based on user 1), then its received signal can be written as:

$$y_1 = G_1 H_1 W_1 s_1 + \sum_{k, k \neq 1} G_1 H_k W_k s_k + G_1 i_{oci,1} + G_1 n_1$$

Define

$$\begin{aligned} R_k &\equiv H_1 W_k W_k^H H_1^H, \\ R_{oci} &\equiv i_{oci} i_{oci}^H, \\ R_n &\equiv n n^H \end{aligned}$$

then the ideal equivalent channel SINR for CQI selection can be written as:

$$SINR_{1,eff} = \frac{E\{tr(G_1 R_1 G_1^H)\}}{E\left\{tr\left(\sum_{k, k \neq 1} G_1 R_k G_1^H\right)\right\} + E\{tr(G_1 R_{oci} G_1^H)\} + E\{tr(G_1 R_n G_1^H)\}}$$

$\underbrace{\hspace{10em}}_{MUI} \qquad \underbrace{\hspace{5em}}_{OCI} \qquad \underbrace{\hspace{5em}}_{Noise}$

In the above equation, MUI represents multiple user interference, OCI represents the other cell interference and Noise represents noise.

A TM2 $R_{k, TM2}, k = 1, \dots, K$ (autocorrelation matrix for a channel under transmission mode TM2) is used by the UE to calculate TDD CQI feedback, although ideally a TMx $R_{k, TMx}$ (autocorrelation matrix for a channel under transmission mode TMx) should be used. The TDD eNB needs to compensate this with a factor. Presently, this factor is normally obtained from an open-loop link adaptation (OLLA) mechanism based on higher layer ACK/NACKs from the UE. But since OLLA needs time to converge, it is ineffective for scenarios where the precoder changes rapidly, i.e.,

1) multi-user scenario where the precoder may change per TTI with user-pairing;

2) rank adaptation scenario where the precoder may change per TTI with rank adaptation.

By assuming that the TDD MU-MIMO scheme is a zero-forcing scheme which is generally the case for most practical systems, the MUI term in the nominator can be eliminated. Then the SINR gain gap between TMx and TM2 can be written as:

$$\begin{aligned}\Delta_{SINR} &= SINR_{1, TMx} / SINR_{1, TM2} \\ &= \frac{E\{tr(G_1 R_{1, TMx} G_1^H)\}}{E\{tr(G_1 R_{1, TM2} G_1^H)\}} \\ &= \frac{E\{tr(R_{1, TMx} R_{G_1})\}}{E\{tr(R_{1, TM2} R_{G_1})\}}\end{aligned}\quad (1)$$

where

$$R_{G_1} \equiv G_1^H G_1 \quad (2)$$

In this equation, both $R_{1, TMx}$ and $R_{1, TM2}$ are perfectly known at the TDD eNB side owing to the TDD channel reciprocity. The only unknown parameter to the eNB is the left side covariance R_{G_1} of the user receiver, which is a product of a receiver matrix and its transport matrix.

Based on the observation from (1), the following proposal is proposed:

Proposal 1:

For a general TMx 3D MIMO system, a UE can measure and feedback a TM2 CQI, and simultaneously feedback a CQI differential indicator for indicating the gain of TMx over TM2. The eNB will derive the TMx CQI based on this TM2 CQI and this extra indicator.

In practical systems, such a gain can be measured by the UE in a predefined way and feedback to the eNB for CQI fine-tuning. For example, it can based on the following proposal:

Herein, eNB can derive the CQI differential by comparing the DMRS based channel quality and the TM2 based channel quality.

In the following, an exemplary method of deriving a CQI differential indicator would be described.

As shown in Figure 1, in step S101, UE determines a DMRS based CQI of another transmission mode TMx based on the DMRS in the previous TTI. Specifically, UE can measure the effective receiving SINR, which is denoted as $SINR_{1,DMRS}$, based on the DMRS in the previous TTI. After then, this value is converted to a corresponding DMRS based CQI.

In step S102, UE determines the CQI of the transmission mode TM2.

In step S103, UE determines the number of antenna ports under another transmission mode TMx. This could be obtained by high layer configuration information, for example.

Then, in step S104, UE will determine a transmission mode offset level for the current data stream (i.e., for the current rank) based on the DMRS based CQI, the CQI of the transmission mode TM2 and the number of the antenna ports.

For example, this could be obtained by the following equation:

Transmission mode offset level of the current rank = TM2 CQI index + $10 \cdot \log_{10}(\text{Number of TX Antenna Ports}) - \text{DMRS CQI index}$ for the current rank

Lastly, in step S105, UE determines the CQI differential indicator according to the obtained transmission mode offset level. This could be obtained by the mapping relationship as shown in Table 1. Table 1 shows a mapping relationship between the CQI differential value and the offset level.

TMx CQI differential value	Offset level
0	≤ 0
1	1
2	2

3	≥ 3
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Table 1 Mapping transmission mode CQI differential value to offset level

Then, in step S106, UE will use 2-bits CQI differential indicator to report to the eNB the CQI differential value for the current user and the current data stream, which indicates the offset level of $CQI_{1, TM2}$ in the transmission mode TX2 relative to $CQI_{1, DMRS}$ of another transmission mode.

Scheme 2 would be discussed in the following. Different from scheme 1, scheme 2 does not rely on the measurement for DMRS.

In this scheme, for a general TMx 3D MIMO system, a UE can measure and feedback a TM2 CQI. In the present invention, the UE will simultaneously feedback a single or multiple CQI differential indicator(s) for indicating the per data stream (i.e., rank) relative receiving gain λ_i^2 / P_{norm} . Herein, λ_i^2 is the eigen power for rank i, and λ_i is the element corresponding to rank i in the leading diagonal of an equivalent channel matrix. Herein, the equivalent channel matrix is with respect to the receiver of the UE. Therefore, for one rank, there is a relative receiving gain, and there is a CQI differential indicator. The eNB will derive the TMx CQI based on the TM2 CQI and the CQI differential indicator(s).

In practice, the feedback number of CQI differential indicators is determined by the number of ranks scheduled for the UE by the eNB.

Parameter P_{norm} in the relative receiving gain λ_i^2 / P_{norm} is a power normalization factor. For example, it could be determined with regard to the TM2 equivalent channel power in order to facilitate the CQI differential indicator derivation and feedback based on the existing LTE/LTE-A CQI table.

In the following, an exemplary method of deriving a CQI differential indicator would be described.

As shown in Figure.2, in step S201, the equivalent receiving power of transmission mode TM2 is converted into a normalization factor, that

is:

$$P_{norm} = E\{tr(R_{1, TM2} R_{G_i})\}$$

In the above equation, $R_{1, TM2}$ is a channel autocorrelation matrix in the transmission mode TM2. R_{G_i} is a product of a receiver matrix and its transport matrix.

Then, in step S202, the relative receiving gain λ_i^2 / P_{norm} is determined for the current data stream, rank i, for example.

In step S203, SINR for the transmission mode TM2 is determined.

In step S204, the number of the antenna ports under another transmission mode TMx is determined. This could be obtained by high layer configuration information, for example.

Then, in step S205, the CQI offset level of the receiver for the current data stream (i.e., for the current rank) is determined according to SINR, the number of the antenna ports and the relative receiving gain.

For example, it could be obtained by the following equation:

Receiver CQI offset level of the current rank i =

CQI level for (TM2 SINR + 10*log10(Number of TX Ports)) - CQI level for (TM2 SINR + 10*log10(λ_i^2 / P_{norm})).

Then, in step S206, UE will determine the CQI differential indicator according to the CQI offset level. This could be obtained by the mapping relationship shown in Table 2. Table 2 shows the mapping relationship between the CQI differential value of the receiver and the offset level.

TMx CQI differential value	Offset level
0	≤ 0
1	1
2	2
3	≥ 3

Table 2 Mapping transmission mode CQI differential value to offset level

Then, in step S207, UE uses 2-bit CQI differential indicator to report the offset level of $CQI_{1, TM2}$ of TM2 relative to $CQI_{1, TMx}$ of another transmission mode for the current user and the current data stream/rank considering the power boosting by the receiver to the eNB.

Figure 3 shows a flowchart of a method of improving the channel quality feedback in an eNB in a non-codebook based 3D MIMO system according to an embodiment of the present invention. The eNB is responsible for reconstructing TMx CQI from the TM2 CQI and the CQI differential by following the procedure given below:

$$CQI_{TM2} \longrightarrow SINR_{TM2} \xrightarrow{+IdealArrayGain} SINR_{IdealTMx} \longrightarrow CQI_{IdealTMx} \xrightarrow{-\Delta CQI_i} CQI_{TMx}$$

It will be described in detail with respect to Fig.3. As shown in Fig.3, in step S301, the eNB receives a TM2 CQI and a differential indicator from UE, which indicates a relative gain of another transmission mode relative to the transmission mode TM2 or indicates a relative receiving gain for the data stream configured for the UE.

In step S302, the eNB determines the SINR for the transmission mode TM2 according to the CQI of the transmission mode TM2.

In step S303, the eNB determines the ideal SINR for another transmission mode according to the number of the antenna ports under the another transmission mode and the SINR for the transmission mode TM2.

In step S304, the eNB determines the ideal channel quality indicator of the another transmission mode according to the ideal SINR.

In step S305, the eNB corrects the ideal channel quality indicator with the differential indicator to determine a channel quality indicator of another transmission mode.

In the following, scheme 3 is further proposed according to equation 2.

Scheme 3:

For a general TMx 3D MIMO system, a UE can measure and feedback a TM2 CQI. In scheme 3, a first indication message would be

feedback simultaneously, which is used to indicate the left autocorrelation receiver matrix R_{G1} in equation 2. The eNB will derive the TMx CQI based on this TM2 CQI and the above first indication message.

For a single antenna UE, the left autocorrelation receiver matrix is reduced into a scalar, and will not impact the value of Δ_{SINR} in equation 1, and thus does not need feedback. Hence, a simple TM2 CQI would be sufficient for single antenna TDD UEs to achieve optimum performance.

For UEs with larger number of antennas, by writing the receiver matrix into its SVD decomposition, it will become:

$$R_{G_1} \equiv V_{G_1} \Sigma_{G_1}^2 V_{G_1}^H$$

Where V_{G_1} is the eigen vector of G_1 and $\Sigma_{G_1}^2$ is the eigen power of G_1 . The eigen vector V_{G_1} can be quantized and feedback as a receiver matrix indicator (RMI). The on-leading diagonal elements (i.e., eigen power for different data streams, i.e. ranks) of $\Sigma_{G_1}^2$ can be quantized and feedback.

In the following, the scheme would be discussed in detail.

For a general TMx 3D MIMO system, a UE can measure and feedback a TM2 CQI. In this scheme 3, the UE will simultaneously feedback a receiver matrix indicator (RMI) for indicating the receiver matrix eigen vector, and a single or multiple CQI differential indicators for indicating the relative eigen power λ_i^2 / P_{norm} . Herein, λ_i^2 is the eigen power for rank i, and λ_i is the element corresponding to rank i in the leading diagonal of the receiver matrix. Therefore, for one rank, there is a relative eigen power, and there is a CQI differential indicator. The eNB will derive the TMx CQI based on the TM2 CQI and the CQI differential indicator(s).

Herein, the number of RMIs and CQI differential feedbacks is determined by the number of ranks scheduled for the UE by the eNB.

Parameter P_{norm} in the relative eigen power λ_i^2 / P_{norm} is a power normalization factor. For example, it could be determined with regard

to the TM2 equivalent channel power in order to facilitate the CQI differential indicator derivation and feedback based on the existing LTE/LTE-A CQI table.

In the following, an exemplary method of deriving a CQI differential indicator would be described.

As shown in Figure.4, in step S401, the equivalent receiving power of transmission mode TM2 is converted into a normalization factor, that is:

Firstly, the equivalent receiving power of TM2 is converted into a normalization factor:

$$P_{norm} = E\{tr(R_{1,TM2} R_{G_i})\}$$

In the above equation, $R_{1,TM2}$ is a channel autocorrelation matrix in the transmission mode TM2. R_{G_i} is a product of a receiver matrix and its transport matrix.

Then, in step S402, the relative eigen power λ_i^2 / P_{norm} is determined for the current data stream, rank i, for example. In step S403, the number of the antenna ports under another transmission mode TMx is determined. This could be obtained by high layer configuration information, for example.

In step S404, the CQI offset level of the receiver is determined according to the number of the antenna ports and the relative eigen power.

For example, it could be obtained by the following equation:

Receiver CQI offset level of the current rank i =

CQI level for $10 \cdot \log_{10}(\text{Number of TX Ports})$ - CQI level for $10 \cdot \log_{10}(\lambda_i^2 / P_{norm})$.

Then, in step S405, the UE will determine the CQI differential indicator according to the CQI offset level. This could be obtained by the mapping relationship shown in Table 3. Table 3 shows the mapping relationship between the CQI differential value of the receiver and the offset level.

TMx CQI differential value	Offset level
0	≤ 0
1	1
2	2
3	≥ 3

Table 3 Mapping transmission mode CQI differential value to offset level

Then, in step S406, UE uses 2-bit CQI differential indicator to indicate the CQI differential value, so as to report the offset level of $CQI_{1, TM2}$ of TM2 relative to $CQI_{1, TMx}$ of another transmission mode for the current user and the current data stream/rank considering the power boosting by the receiver to the eNB.

Herein, the parameter λ_i^2 is the eigen power for rank i. Table 3 shows a mapping relationship between the 2-bit receiver CQI differential value and the offset level.

TMx CQI differential value	Offset level
0	≤ 0
1	1
2	2
3	≥ 3

Table 2 Mapping transmission mode CQI differential value to offset level

Figure 5 shows a flowchart of a method of improving the channel quality feedback in an eNB in a non-codebook based 3D MIMO system according to a further embodiment of the present invention.

In step S501, the eNB receives a TM2 CQI and a first indication message from UE, which indicates a left autocorrelation receiver matrix, and wherein the left autocorrelation receiver matrix is a product of a receiver matrix and its transport matrix.

In step S502, the eNB obtains a channel autocorrelation matrix under the transmission mode TM2 and a channel autocorrelation matrix

under another transmission mode based on channel reciprocity.

In step S503, the eNB determines the SINR relative gain of the another transmission mode relative to the transmission mode TM2 according to the left autocorrelation receiver matrix, the channel
5 autocorrelation matrix under the transmission mode TM2 and the channel autocorrelation matrix under another transmission mode.

In step S504, the eNB determines the SINR of the transmission mode TM2 according to the TM2 CQI.

In step S505, the eNB determines the SINR of another
10 transmission mode according to the SINR relative gain and the SINR of the transmission mode TM2.

In step S506, the eNB determines the CQI of another transmission mode based on the SINR of the another transmission mode.

In sum, the disclosure introduces some additional indicators to
15 correct the current TM2 CQI, so as to enhance the CQI of non-codebook based systems. The enhancement will enable more adaptive resource scheduling for higher order spatial multiplexing and higher order MU-MIMO. With the CQI enhancement, the performance of non-codebook based systems such as LTE/LTE-A TDD systems will
20 be improved and the link performance will be more stable.

It shall be appreciated that the foregoing embodiments are merely illustrative but will not limit the invention. Any technical solutions without departing from the spirit of the invention shall fall into the scope of invention, including that different technical features, methods
25 appearing in different embodiments are used to combine to advantage. Besides, any reference numerals in the claims shall not be taken as limiting the claims where they appear. Furthermore it will be apparent that the term “comprise” will not preclude another element(s) or step(s), and the term “a/an” preceding an element will not preclude “a plurality
30 of” such elements.

CLAIMS

1. A method, in a user equipment, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method
5 comprising:

transmitting a channel quality indicator of a transmission mode TM2 and a differential indicator to an eNB, the differential indicator indicating a relative gain of another transmission mode relative to the transmission mode TM2.

10 2. A method according to claim 1, characterized in that, the differential indicator is determined by comparing DMRS based channel quality of the another transmission mode with channel quality of the transmission mode TM2.

3. A method according to claim 2, characterized in that:
15 determining a DMRS based channel quality indicator of the another transmission mode based on DMRS in a previous TTI;

determining a channel quality indicator of the transmission mode TM2;
determining number of antenna ports under the another transmission mode;

20 determining a transmission mode offset level according to the DMRS based channel quality indicator, the channel quality indicator of the transmission mode TM2 and the number of the antenna ports; and

determining the differential indicator according to the transmission mode offset level.

25 4. A method according to claim 1, characterized in that, the another transmission mode at least includes transmission mode TM7, TM8, TM9 and TM10.

5. A method, in a user equipment, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method
30 comprising:

transmitting a channel quality indicator of a transmission mode TM2

and at least one differential indicator to an eNB, wherein each differential indicator is used to indicate a relative receiving gain for a data stream configured for the user equipment, respectively.

6. A method according to claim 5, characterized in that,
5 determining SINR for the transmission mode TM2;
determining number of antenna ports under another transmission mode;
determining the relative receiving gain as a quotient of an eigen power of an equivalent channel matrix under the another transmission mode for the data stream and a normalization factor;

10 determining a offset level of a channel quality indicator of a receiver according to the SINR, the number of the antenna ports and the relative receiving gain; and

determining the differential indicator according to the offset level.

7. A method according to claim 6, characterized in that, the
15 normalization factor is determined according to a channel autocorrelation matrix under the transmission mode TM2, a receiver matrix and its transport matrix.

8. A method according to claim 6, characterized in that, the another transmission mode at least includes transmission mode TM7, TM8, TM9 and
20 TM10.

9. A method, in an eNB, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method comprising:

receiving a channel quality indicator of a transmission mode TM2 and a differential indicator from a user equipment, wherein the differential indicator
25 is used to indicate a relative gain of another transmission mode relative to the transmission mode TM2 or a relative receiving gain for a data stream configured for the user equipment;

determining SINR for the transmission mode TM2 according to the channel quality indicator of the transmission mode TM2;

30 determining an ideal SINR for the another transmission mode according to number of the antenna ports under the another transmission

mode and the SINR for the transmission mode TM2;

determining an ideal channel quality indicator of the another transmission mode according to the ideal SINR;

correcting the ideal channel quality indicator with the differential
5 indicator to determine a channel quality indicator of the another transmission mode.

10. A method according to claim 9, characterized in that, the another transmission mode at least includes transmission mode TM7, TM8, TM9 and TM10.

10 11. A method, in a user equipment, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method comprising:

transmitting a channel quality indicator of a transmission mode TM2 and a first indication message to an eNB, wherein the first indication message
15 is used to indicate a left autocorrelation receiver matrix, and the left autocorrelation receiver matrix is a product of a receiver matrix and its transport matrix.

12. A method according to claim 11, characterized in that, the first indication message includes: a receiver matrix indicator and at least one
20 differential indicator, wherein each differential indicator is used to indicate a relative eigen power for a data stream configured for the user equipment, respectively.

13. A method according to claim 12, characterized in that,
determining number of antenna ports under another transmission mode;
25 determining the relative eigen power as a quotient of an eigen power of a receiver matrix under the another transmission mode for the data stream and a normalization factor;

determining a offset level of a channel quality indicator of a receiver according to the number of the antenna ports and the relative eigen power;

30 and

determining the differential indicator according to the offset level.

14. A method according to claim 13, characterized in that, the normalization factor is determined according to a channel autocorrelation matrix under the transmission mode TM2, a receiver matrix and its transport matrix.

5 15. A method, in an eNB, of improving channel quality feedback in a non-codebook based 3D MIMO system, the method comprising:

receiving a channel quality indicator of a transmission mode TM2 and a first indication message from a user equipment, wherein the first indication message is used to indicate a left autocorrelation receiver matrix, and the left autocorrelation receiver matrix is a product of a receiver matrix and its
10 transport matrix;

obtaining a channel autocorrelation matrix under the transmission mode TM2 and a channel autocorrelation matrix under another transmission mode based on channel reciprocity;

15 determining a SINR relative gain of the another transmission mode relative to the transmission mode TM2 according to the left autocorrelation receiver matrix, the channel autocorrelation matrix under the transmission mode TM2 and the channel autocorrelation matrix under another transmission mode;

20 determining SINR of the transmission mode TM2 according to the channel quality indicator of the transmission mode TM2;

determining SINR of the another transmission mode according to the SINR relative gain and the SINR of the transmission mode TM2; and

determining a channel quality indicator of the another transmission
25 mode based on the SINR of the another transmission mode.

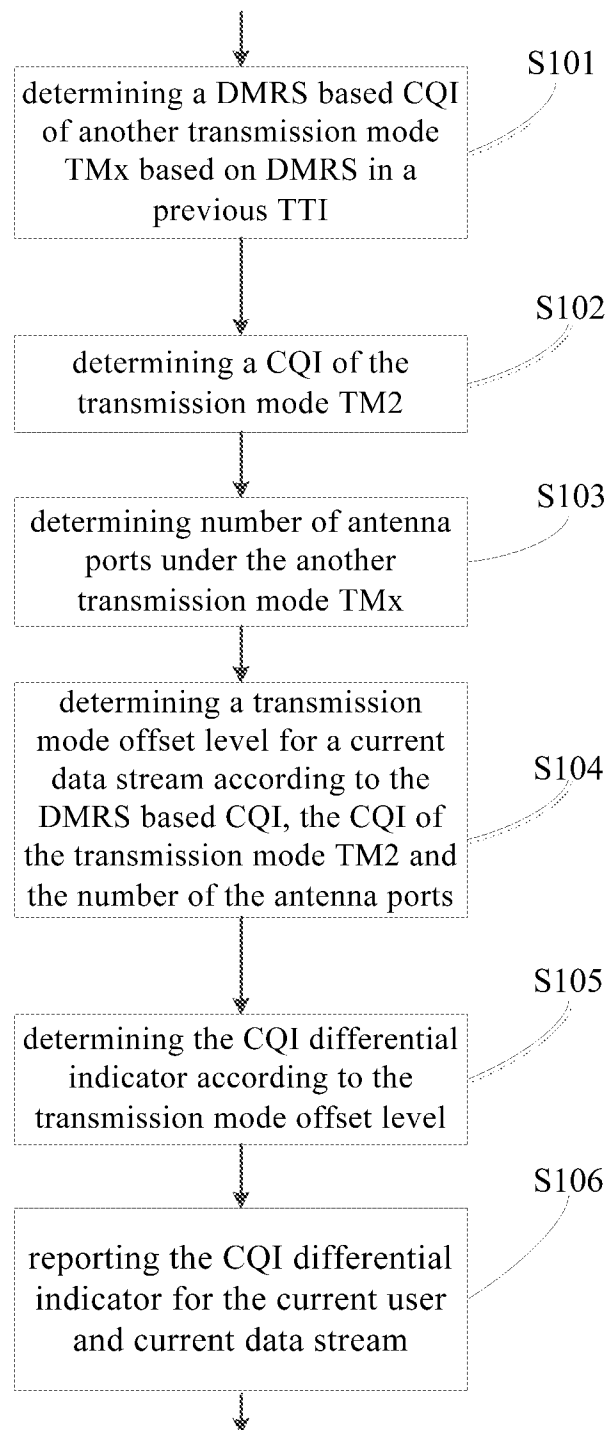


Fig.1

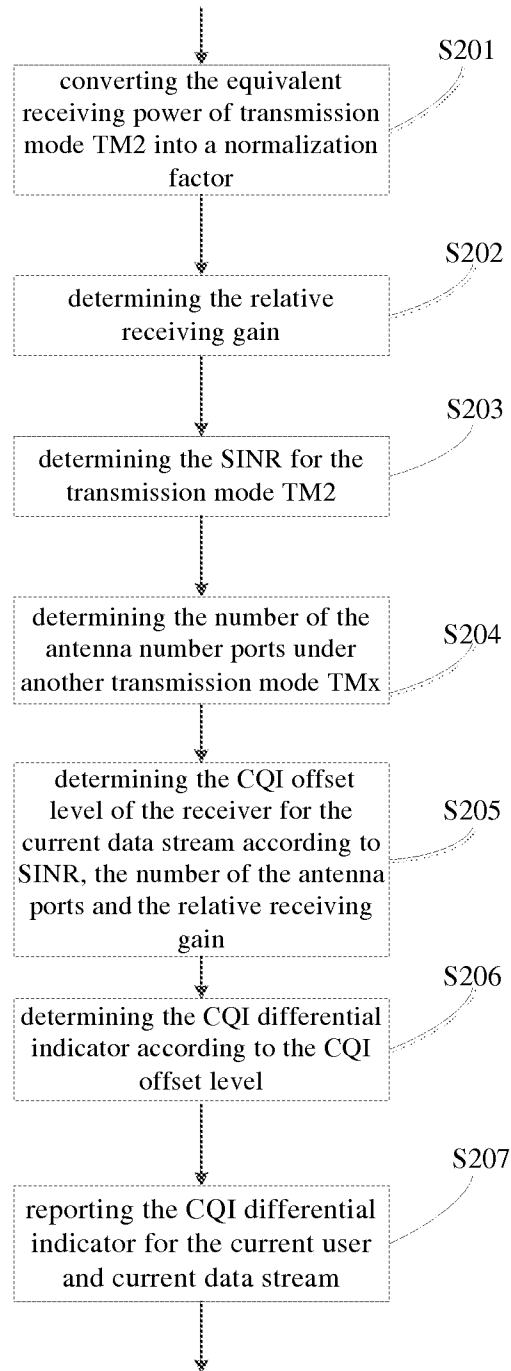


Fig.2

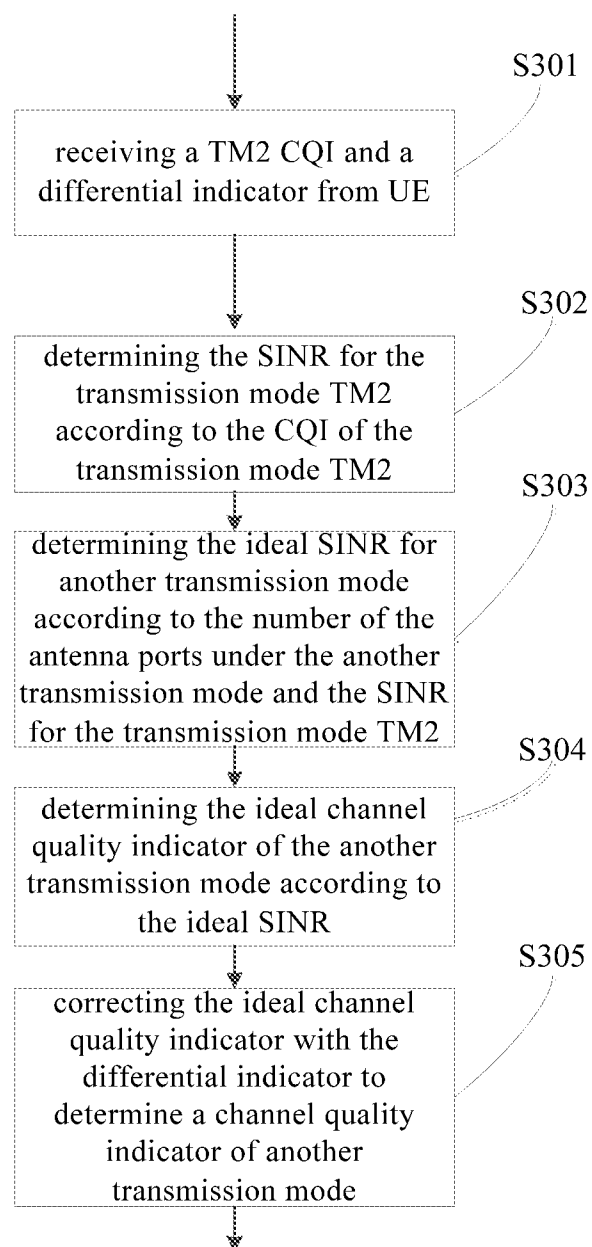


Fig.3

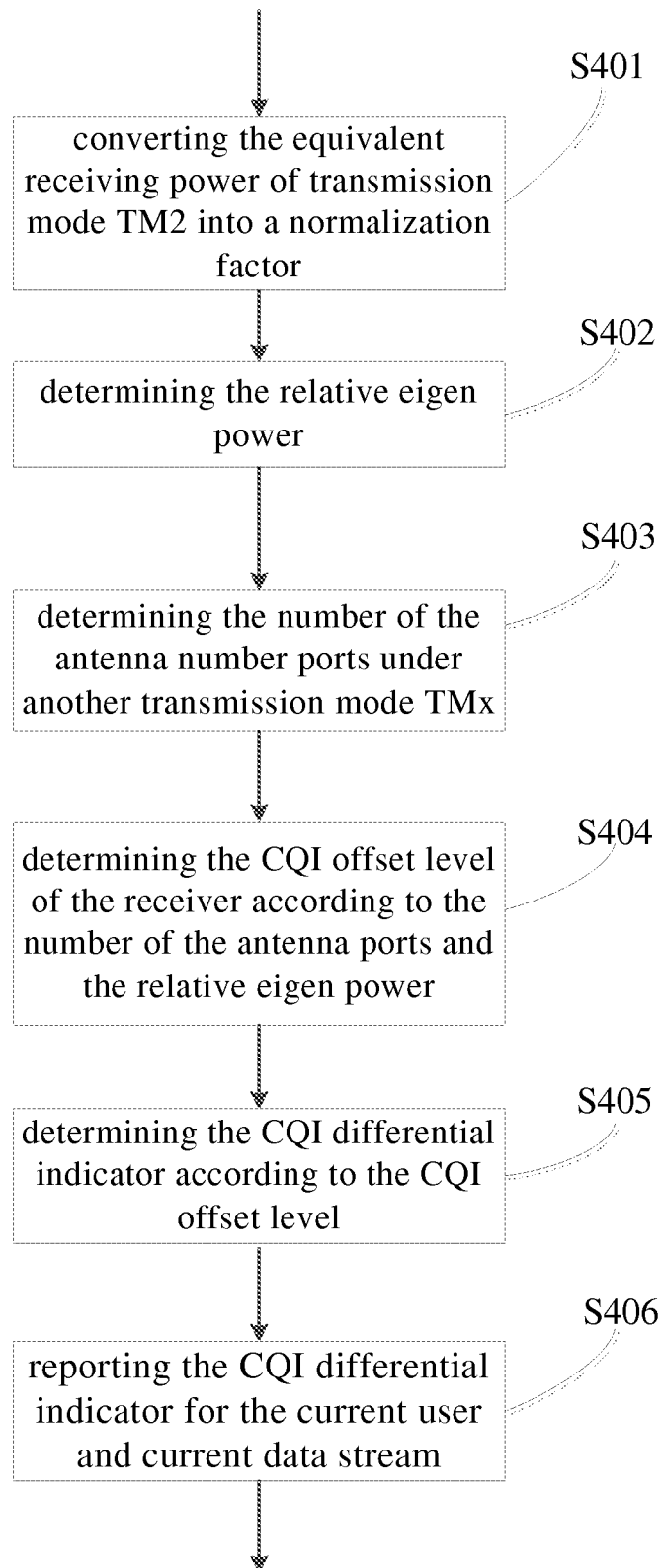


Fig.4

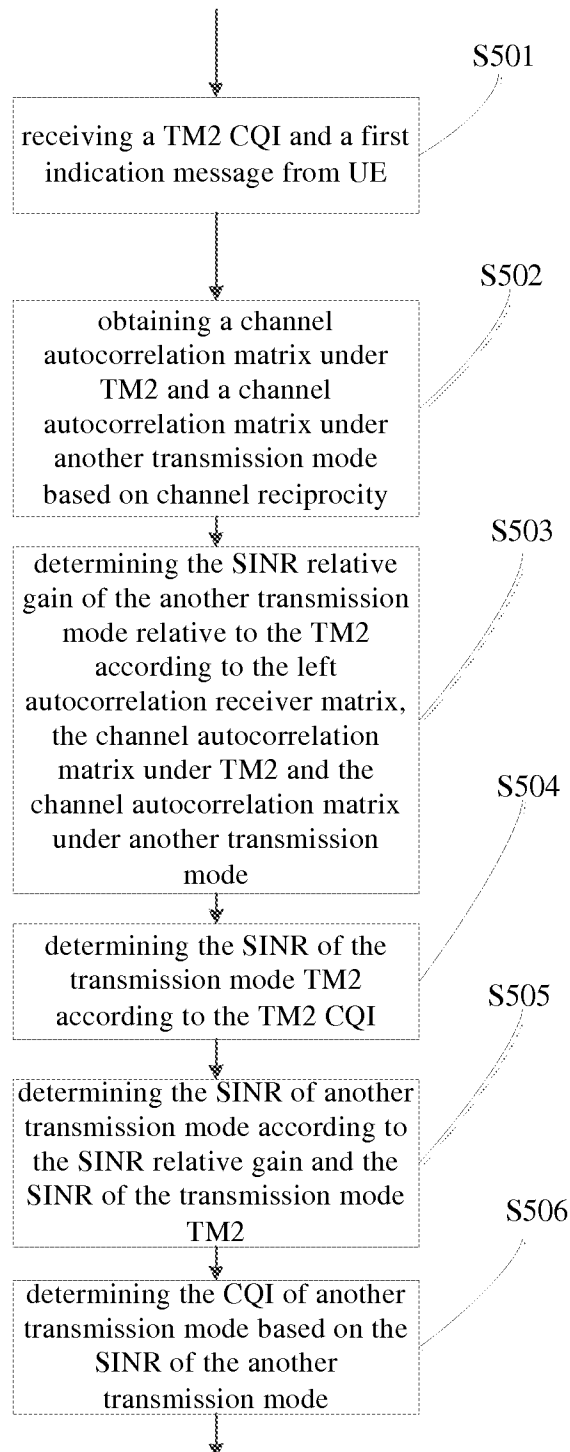


Fig.5