

UPLINK PRECODING METHOD, DEVICE AND SYSTEM

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TECHNICAL FIELD

The disclosure relates to a wireless network technology, and more particularly to an uplink pre-coding method, a device and a system.

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BACKGROUND

A terminal device, before sending uplink data, needs to perform pre-coding processing on the uplink data to obtain an uplink pre-coding gain.

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Pre-coding processing is usually classified into two parts: analogue domain processing and digital domain processing. Analogue domain processing is directed to an analogue signal, and a radio frequency signal is usually mapped to a physical antenna in a beamforming manner. Digital domain processing is directed to a digital signal, and is usually implemented in baseband. The digital signal is pre-coded with a pre-coding matrix, and data at a transmission layer is mapped to a radio frequency port.

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Due to the limited number of radio frequency channels of a terminal device, two processing manners are usually adopted at the same time, namely the digital signal is pre-coded and the analogue signal is beamformed.

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In a codebook-based uplink pre-coding scheme, the terminal device may send sounding reference signals (SRSs) on multiple SRS resources. Here, the SRS on each SRS resource uses a different beam. The network side selects the best SRS resource to obtain uplink channel state information (CSI) and indicates a resource index to the terminal device through an SRS resource indication (SRI), such that the terminal device may perform analogue beamforming on uplink data by use of the beam corresponding to the SRS resource. Meanwhile, the network side may indicate a rank indication (RI) and a pre-coding matrix indication (PMI) through downlink control information (DCI), and the terminal device may determine an uplink pre-coding matrix corresponding to the PMI from a codebook according to the RI and the PMI.

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It can be seen that, according to the existing processing manner, it is necessary

for the DCI to include various information such as an RI, a PMI and an SRI, so that a relatively high signaling overhead is required.

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SUMMARY

In view of this, the disclosure provides an uplink pre-coding method, a device and a system, which can reduce a signaling overhead.

The following technical solutions are adopted.

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An uplink pre-coding method may include the following operations.

A terminal device transmits an SRS on at least one SRS resource.

The terminal device receives DCI for scheduling uplink data transmission from a network side. The DCI includes an RI and/or an SRI.

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The terminal device determines a pre-coding scheme for uplink data according to at least one SRS resource and at least one of the RI and the SRI.

The terminal device pre-codes the uplink data according to the pre-coding scheme, and sends the pre-coded uplink data.

An uplink pre-coding method may include the following operations.

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A network-side device acquires an SRS transmitted by a terminal device on at least one SRS resource.

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The network-side device sends DCI for scheduling uplink data transmission to the terminal device. The DCI includes an RI and/or an SRI, and is used for the terminal device to determine a pre-coding scheme for uplink data according to the at least one SRS resource and at least one of the RI and the SRI, and pre-code the uplink data according to the pre-coding scheme.

The network-side device receives the pre-coded uplink data sent by the terminal device.

A terminal device may include an information processing unit, a pre-coding scheme determination unit and an uplink data processing unit.

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The information processing unit may be configured to transmit an SRS on at least one SRS resource and receive DCI for scheduling uplink data transmission from a network side. The DCI includes an RI and/or an SRI.

The pre-coding scheme determination unit may be configured to determine a pre-coding scheme for uplink data according to at least one SRS resource and at least

one of the RI and the SRI.

The uplink data processing unit may be configured to pre-code the uplink data according to the pre-coding scheme and send the pre-coded uplink data.

5 A network-side device may include a first processing unit and a second processing unit.

The first processing unit may be configured to acquire an SRS transmitted by a terminal device on at least one SRS resource and send DCI for scheduling uplink data transmission to the terminal device. The DCI includes an RI and/or an SRI, and is used for the terminal device to determine a pre-coding scheme for uplink data
10 according to the at least one SRS resource and at least one of the RI and the SRI, and pre-code the uplink data according to the pre-coding scheme.

The second processing unit may be configured to receive the pre-coded uplink data from the terminal device.

15 An uplink pre-coding system may include the abovementioned terminal device and the abovementioned network-side device.

Based on the above introductions, it can be seen that, with adoption of the solutions of the disclosure, the DCI sent to the terminal device by the network side merely needs to include one or two of the RI and the SRI, and then the terminal device may determine the pre-coding scheme for the uplink data according to the RRI
20 and/or the SRI, etc., and further pre-code and send the uplink data. Therefore, compared with the prior art, the solutions have an advantage that a signaling overhead of the DCI is reduced.

25 BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 illustrates a flowchart of an uplink pre-coding method according to an embodiment of the disclosure.

30 FIG. 2 illustrates a block diagram of a terminal device according to an embodiment of the disclosure.

FIG. 3 illustrates a block diagram of a network-side device according to an embodiment of the disclosure.

35 DETAILED DESCRIPTION

For making the technical solutions of the disclosure clearer, the solutions of the disclosure will further be described below with reference to the drawings and embodiments.

5 It is apparent that the described embodiments are not all embodiments but part of embodiments of the disclosure. All other embodiments obtained by those skilled in the art on the basis of the embodiments in the disclosure without creative work shall fall within the scope of protection of the disclosure.

FIG. 1 is a flowchart of an uplink pre-coding method embodiment according to
10 the disclosure. As shown in FIG. 1, the following implementation modes are included.

In 100, a terminal device transmits an SRS on at least one SRS resource.

The at least one SRS resource refers to that the number of SRS resources may be 1 and may also be more than 1.

A single antenna port is adopted for each of the at least one SRS resource.

15 Or, N antenna ports are adopted for each of the at least one SRS resource.

Or, the at least one SRS resource comprises K SRS resources, and k antenna ports are adopted for the k^{th} SRS resource of the K SRS resources.

N is a number of ports for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.

If a value of K is 4, one antenna port may be adopted for the first SRS
20 resource, two antenna ports may be adopted for the second SRS resource, three antenna ports may be adopted for the third SRS resource and four antenna ports may be adopted for the fourth SRS resource.

In a practical application, the terminal device may determine a beam for transmitting the SRS according to downlink channel information obtained from a
25 downlink signal. For example, the terminal device may determine the beam for transmitting the SRS according to a receiving beam receiving the downlink signal.

The beam is a beam for analogue beamforming, and is invisible for the network side.

The downlink signal may be indicated to the terminal device through a PMI
30 domain in DCI.

In addition, the downlink signal may be a downlink reference signal or a downlink synchronization signal.

In 101, the terminal device receives DCI for scheduling uplink data

transmission from a network side. The DCI includes an RI and/or an SRI.

The DCI does not include information for indicating a pre-coding matrix for uplink data.

5 The DCI may not include a PMI information domain. Or, the DCI may include the PMI information domain, but the PMI information domain is not used to indicate the pre-coding matrix but to indicate other information, for example, an antenna port.

The DCI includes at least one of the RI and the SRI, namely the DCI may include the RI or the SRI only, or may include both the RI and the SRI. A content thereof may be configured by the network side.

10 In 102, the terminal device determines a pre-coding scheme for uplink data according to the RI and/or the SRI, as well as the at least one SRS resource.

The pre-coding scheme includes at least one of: a beam for analogue domain beamforming, and a pre-coding matrix for digital domain pre-coding. The terminal device may also combine analogue beamforming and digital pre-coding to obtain a
15 joint pre-coding matrix as the pre-coding scheme for the uplink data.

In the embodiment, five preferred implementation manners are provided for how the terminal device determines the pre-coding scheme for the uplink data, and will be introduced below respectively.

1) A first manner

20 The terminal device may determine one or more target SRS resources from the at least one SRS resource according to the RI and the SRI, and further determine the pre-coding scheme for the uplink data according to a pre-coding scheme for the target SRS resources.

The terminal device may firstly determine the number of the target SRS
25 resources according to the RI, and then may determine the target SRS resources according to the number of the target SRS resources and the SRI.

For a different number of the target SRS resources, a correspondence relationship between SRIs and target SRS resources is also different.

If the at least one SRS resource includes four SRS resources, corresponding to
30 different rank values indicated by the RI (2bits), a correspondence relationship between SRIs and SRS resources may be shown in Table 1, the rank value is equal to the number of the target SRS resources.

SRI value (3bits)	Index of the target SRS resources			
	Rank=1	Rank=2	Rank=3	Rank=4
0	0	{0, 1}	{0, 1, 2,}	{0, 1, 2, 3}
1	1	{0, 2}	{0, 1, 3}	-
2	2	{0, 3}	{0, 2, 3}	-
3	3	{1, 2}	{1, 2, 3}	-
4	-	{1, 3}	-	-
5	-	{2, 3}	-	-
6	-	-	-	-
7	-	-	-	-

Table 1 Correspondence Relationship between SRIs and SRS Resources

In this manner, a single antenna port is adopted for each of the at least one SRS resource.

Each target SRS resource corresponds to an uplink transmission layer, and when the terminal device determines the pre-coding scheme for the uplink data, a beam and pre-coding matrix for each target SRS resource may be determined as a beam and pre-coding matrix for transmission of a transmission layer.

2) A second manner

The terminal device may determine a transmission layer number according to the RI, determine the pre-coding matrix for the uplink data according to the transmission layer number and uplink channel information, determine the target SRS resource from the at least one SRS resource according to the SRI, determine a beam for the uplink data according to a beam for the target SRS resource and obtain the pre-coding scheme for the uplink data according to the determined pre-coding matrix and beam.

In this manner, there is no fixed sequence for processes of determining the beam and determining the pre-coding matrix.

The terminal device may obtain the uplink channel information according to the downlink channel information obtained based on the downlink signal.

The downlink signal may be indicated to the terminal device through the PMI domain in the DCI.

In addition, the downlink signal may be a downlink reference signal or a downlink synchronization signal.

The terminal device, after determining the transmission layer number according to the RI, may determine the pre-coding matrix for the uplink data based on the transmission layer number and the uplink channel information. For example, first R feature vectors in an uplink channel related matrix or covariance matrix in the uplink channel information may be determined as the pre-coding matrix for the uplink data, where R represents the transmission layer number.

In this manner, N antenna ports are adopted for each of the at least one SRS resource, where N is a number of ports for uplink data transmission.

In addition, in this manner, the number of the target SRS resource is usually 1, the SRI may contain an index of the target SRS resource, and after the target SRS resource is determined, the beam for the target SRS resource may be determined as the beam for the uplink data.

It can be seen that, in this manner, the pre-coding matrix for the uplink data is determined through the RI and the uplink channel information, and the beam for the uplink data is determined through the SRI, thereby obtaining the pre-coding matrix for the uplink data.

3) A third manner

The terminal device may determine the transmission layer number according to the RI, determine the pre-coding matrix for the uplink data according to the transmission layer number and the uplink channel information, determine the beam for the uplink data according to a beam for the at least one SRS resource, and obtain the pre-coding scheme for the uplink data according to the determined pre-coding matrix and beam.

In this manner, the DCI with the RI does not include indication information of the SRS resource. The DCI may not include an SRI information domain. Or, the DCI may include the SRI information domain, but the SRI information domain is not used to indicate the SRS resource, but to indicate other information, for example, an antenna port.

The terminal device may obtain the uplink channel information according to the downlink channel information obtained based on the downlink signal.

The downlink signal may be indicated to the terminal device through the PMI

domain in the DCI.

In addition, the downlink signal may be a downlink reference signal or a downlink synchronization signal.

5 The terminal device, after determining the transmission layer number according to the RI, may determine the pre-coding matrix for the uplink data based on the transmission layer number and the uplink channel information. For example, the first R feature vectors in the uplink channel related matrix or covariance matrix in the uplink channel information may be determined as the pre-coding matrix for the uplink data, where R represents the transmission layer number.

10 In this manner, N antenna ports are adopted for each of the at least one SRS resource, where N is a number of ports for uplink data transmission.

In addition, in this manner, the at least one SRS resource includes one SRS resource, and the beam for transmitting the SRS on the SRS resource may be determined according to the downlink channel information obtained from the
15 downlink signal. For example, the terminal device may determine the sending beam for transmitting the SRS according to the receiving beam for receiving the downlink signal.

The terminal device, when determining the pre-coding scheme for the uplink data, may determine the beam for the at least one SRS resource as the beam for the
20 uplink data, and determine the pre-coding matrix determined according to the RI and the uplink channel information as the pre-coding matrix for the uplink data.

4) A fourth manner

The terminal device may determine one or more target SRS resources from the at least one SRS resource according to the SRI and determine a pre-coding scheme for
25 the target SRS resource as the pre-coding scheme for the uplink data.

In this manner, the DCI with the SRI does not include indication information of the transmission layer number. The DCI may not include the RI information domain. Or, the DCI may include the RI information domain, but the RI information domain is not used to indicate the transmission layer number but to indicate other
30 information, for example, the antenna port.

The terminal device may determine the transmission layer number according to the number of ports for the target SRS resources or the number of the target SRS resources. If a single antenna port is adopted for each of the at least one SRS resource,

the terminal device may determine the transmission layer number according to the number of the target SRS resources. If the at least one SRS resource includes K SRS resources and k antenna ports are adopted for the k^{th} SRS resource, the terminal device may determine the transmission layer number according to the port number for the target SRS resources.

For example, if a single antenna port is adopted for each of the at least one SRS resource, the SRI may indicate the target SRS resources in the at least one SRS resource in a bitmap manner, the number of the target SRS resources is the transmission layer number, each target SRS resource corresponds to an uplink transmission layer, and the beam and pre-coding matrix for each target SRS resource may be determined as the beam and pre-coding matrix for transmission of a transmission layer respectively.

For another example, if the at least one SRS resource includes K SRS resources and k antenna ports are adopted for the k^{th} SRS resource, where N is a number of ports for uplink data transmission and $1 \leq k \leq K$, $K \leq N$, the SRI may indicate an index of an SRS resource in the K SRS resources as the target SRS resource, the port number for the target SRS resource is the transmission layer number. The network side simultaneously indicates the transmission layer number and the pre-coding scheme in a process of indicating the SRS resource. In such a manner, each target SRS resource corresponds to an uplink transmission layer number. The terminal device adopts beams and pre-coding matrixes for the target SRS resources at the k ports as beams and pre-coding matrixes for transmission of k transmission layers respectively.

5) A fifth manner

The terminal device determines the target SRS resource from the at least one SRS resource according to the RI, and determines the pre-coding scheme for the uplink data according to the pre-coding scheme for the target SRS resource.

In this manner, the DCI with the RI does not include the indication information of the SRS resource. The DCI may not include the SRI information domain. Or, the DCI may include the SRI information domain, but the SRI information domain is not used to indicate the SRS resource but to indicate other information, for example, the antenna port.

In addition, in this manner, the at least one SRS resource includes K SRS

resources, and k antenna ports are adopted for the k^{th} SRS resource, where N is a number of ports for uplink data transmission and $1 \leq k \leq K$, $K \leq N$.

5 In this manner, the number of the target SRS resource is 1, the port number for the target SRS resource is the transmission layer number, and the RI is used for indicating both the transmission layer number and the target SRS resource. For example, if there are k ports for the k^{th} SRS resource, the RI indicates that the transmission layer number is k , and also indicates that the k^{th} SRS resource is the target SRS resource. Each target SRS resource corresponds to an uplink transmission layer number. The terminal device adopts the beams and pre-coding matrixes for the target SRS resources at the k ports as the beams and pre-coding matrixes for transmission of k transmission layers respectively.

The five manners for determining the pre-coding scheme for the uplink data are introduced above. In practical application, the manner to be used may be selected according to a practical condition.

15 For example, the terminal device may determine the manner to be adopted according to indication information of the pre-coding scheme acquired from the network side or the port number for the at least one SRS resource.

The network side may send the indication information of the pre-coding scheme through high-layer signaling and the like. Correspondingly, the terminal device may determine the pre-coding scheme for the uplink data in an indicated manner.

20 Or, the manner may also be determined according to the port number for the at least one SRS resource. For example, if a single antenna port is adopted for each of the at least one SRS resource, and the DCI includes the RI and the SRI, the terminal device may determine the pre-coding scheme for the uplink data in the first manner.

In 103, the terminal device pre-codes the uplink data according to the determined pre-coding scheme, and sends the pre-coded uplink data.

After the pre-coding scheme is determined, the terminal device may pre-code the uplink data by using a known approach and send the pre-coded uplink data.

30 The solutions of the disclosure are described in the method embodiment shown in FIG. 1 mainly from a terminal device side. For a network-side device, the network-side device may acquire the SRS transmitted by the terminal device on the at least one SRS resource, and send the DCI for scheduling uplink data transmission to

the terminal device. The DCI includes at least one of the RI and the SRI, and is used for the terminal device to determine the pre-coding scheme for the uplink data according to the at least one SRS resource and at least one of the RI and the SRI, and pre-code the uplink data according to the determined pre-coding scheme.

5 Correspondingly, the network-side device receives the pre-coded uplink data from the terminal device.

The pre-coding scheme includes the beam for analogue domain beamforming and/or the pre-coding matrix for digital domain pre-coding. The terminal device may also combine analogue beamforming and digital pre-coding to obtain the joint pre-coding matrix as the pre-coding scheme for the uplink data.

The DCI sent by the network-side device does not include the information for indicating the pre-coding matrix for the uplink data, and the terminal device may determine the pre-coding scheme for the uplink data according to the RI and/or SRI in the DCI, the at least one SRS resource, channel reciprocity and the like.

15 A single antenna port is adopted for each of the at least one SRS resource.

Or, N antenna ports are adopted for each of the at least one SRS resource.

Or, the at least one SRS resource includes K SRS resources, and k antenna ports are adopted for the k^{th} SRS resource.

N is the port number for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.

20 The beam for transmitting the SRS may be determined by the terminal device according to the downlink channel information obtained from the downlink signal.

A working mode of the network-side device may refer to corresponding descriptions in the embodiment shown in FIG. 1 and will not be elaborated.

The above is the introduction about the method embodiment, and the solutions of the disclosure will further be described below through a device embodiment.

FIG. 2 is a block diagram of a terminal device embodiment according to the disclosure. As shown in FIG. 2, a terminal device includes an information processing unit 201, a pre-coding scheme determination unit 202 and an uplink data processing unit 203.

30 The information processing unit 201 is configured to transmit an SRS on at least one SRS resource, and receive DCI for scheduling uplink data transmission from a network side. The DCI includes an RI and/or an SRI.

The pre-coding scheme determination unit 202 is configured to determine a

pre-coding scheme for uplink data according to the RI and/or the SRI, as well as the at least one SRS resource.

The uplink data processing unit 203 is configured to pre-code the uplink data according to the pre-coding scheme and send the pre-coded uplink data.

5 The pre-coding scheme includes at least one of: a beam for analogue domain beamforming, and a pre-coding matrix for digital domain pre-coding. The terminal device may also combine analogue beamforming and digital pre-coding to obtain a joint pre-coding matrix as the pre-coding scheme for the uplink data.

10 The DCI does not include information for indicating the pre-coding matrix for the uplink data. The DCI may not include a PMI information domain. Or, the DCI may include the PMI information domain, but the PMI information domain is not used to indicate the pre-coding matrix but to indicate other information, for example, an antenna port.

15 The DCI includes at least one of the RI and the SRI, namely the DCI may include the RI or the SRI only, or may include both the RI and the SRI. A content thereof may be configured by the network side.

A single antenna port is adopted for each of the at least one SRS resource.

Or, N antenna ports are adopted for each of the at least one SRS resource.

20 Or, the at least one SRS resource includes K SRS resources, and k antenna ports are adopted for the k^{th} SRS resource.

N is the port number for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.

In addition, the information processing unit 201 may determine a beam for transmitting the SRS according to downlink channel information obtained from a downlink signal.

25 The pre-coding scheme determination unit 202 may determine the pre-coding scheme for the uplink data in the following five manners.

1) A first manner

30 The pre-coding scheme determination unit 202 may determine one or more target SRS resources from the at least one SRS resource according to the RI and the SRI, and determine the pre-coding scheme for the uplink data according to a pre-coding scheme for the target SRS resources.

The pre-coding scheme determination unit 202 may determine the number of the target SRS resources according to the RI, and further determine the target SRS

resources according to the number of the target SRS resources and the SRI.

In case of different numbers of the target SRS resource, a correspondence relationship between an SRI and a target SRS resource is also different.

5 If the at least one SRS resource includes four SRS resources, corresponding to different rank values indicated by the RI (2bits), a correspondence relationship between an SRI and an SRS resource may be shown in Table 1.

In this manner, a single antenna port is adopted for each of the at least one SRS resource.

10 Each target SRS resource corresponds to an uplink transmission layer, and when the pre-coding scheme determination unit 202 determines the pre-coding scheme for the uplink data, a beam and pre-coding matrix for each target SRS resource may be determined as a beam and pre-coding matrix for transmission of a transmission layer respectively.

2) A second manner

15 The pre-coding scheme determination unit 202 may determine a transmission layer number according to the RI, determine the pre-coding matrix for the uplink data according to the transmission layer number and uplink channel information, determine the target SRS resource from the at least one SRS resource according to the SRI, determine a beam for the uplink data according to a beam for the target SRS
20 resource, and obtain the pre-coding scheme for the uplink data according to the determined pre-coding matrix and beam.

The pre-coding scheme determination unit 202 may obtain the uplink channel information according to the downlink channel information obtained based on the downlink signal.

25 The downlink signal may be indicated to the terminal device through a PMI domain in the DCI.

In addition, the downlink signal may be a downlink reference signal or a downlink synchronization signal.

30 The pre-coding scheme determination unit 202, after determining the transmission layer number according to the RI, may determine the pre-coding matrix for the uplink data based on the transmission layer number and the uplink channel information. For example, first R feature vectors in an uplink channel related matrix or covariance matrix in the uplink channel information may be determined as the pre-

coding matrix for the uplink data, where R represents the transmission layer number.

In this manner, N antenna ports are adopted for each of the at least one SRS resource, where N is a number of ports for uplink data transmission.

3) A third manner

5 The pre-coding scheme determination unit 202 may determine the transmission layer number according to the RI, determine the pre-coding matrix for the uplink data according to the transmission layer number and the uplink channel information, determine the beam for the uplink data according to a beam for the at least one SRS resource, and obtain the pre-coding scheme for the uplink data
10 according to the determined pre-coding matrix and beam.

In this manner, the DCI with the RI does not include indication information of the SRS resource.

15 The pre-coding scheme determination unit 202 may obtain the uplink channel information according to the downlink channel information obtained based on the downlink signal.

The downlink signal may be indicated to the terminal device through the PMI domain in the DCI.

In addition, the downlink signal may be a downlink reference signal or a downlink synchronization signal.

20 In addition, in this manner, N antenna ports are adopted for each of the at least one SRS resource, where N is a number of ports for uplink data transmission.

The at least one SRS resource includes one SRS resource.

25 The pre-coding scheme determination unit 202, when determining the pre-coding scheme for the uplink data, may determine the beam for the at least one SRS resource as the beam for the uplink data, and determine the pre-coding matrix determined according to the RI and the uplink channel information as the pre-coding matrix for the uplink data.

4) A fourth manner

30 The pre-coding scheme determination unit 202 may determine the target SRS resource from the at least one SRS resource according to the SRI and determine the pre-coding scheme for the uplink data according to the pre-coding scheme for the target SRS resource.

In this manner, the DCI with the SRI does not include indication information

of the transmission layer number.

The pre-coding scheme determination unit 202 may determine the transmission layer number according to a number of ports for the target SRS resource or the number of the target SRS resources.

5 For example, if a single antenna port is adopted for each of the at least one SRS resource, the SRI may indicate the target SRS resources in the at least one SRS resource in a bitmap manner, the number of the target SRS resources is the transmission layer number, each target SRS resource corresponds to an uplink transmission layer, and a beam and pre-coding matrix for each target SRS resource
10 may be determined as a beam and pre-coding matrix for transmission of a transmission layer respectively.

For another example, if the at least one SRS resource includes K SRS resources and k antenna ports are adopted for the k^{th} SRS resource, where N is a number of ports for uplink data transmission and $1 \leq k \leq K$, $K \leq N$, the SRI may
15 indicate an index of an SRS resource in the K SRS resources as the target SRS resource, the port number for the target SRS resources is the transmission layer number. The network side simultaneously indicates the transmission layer number and the pre-coding scheme in a process of indicating the SRS resource. In such a manner, each target SRS resource corresponds to an uplink transmission layer number. Beams
20 and pre-coding matrixes for the target SRS resource at the k ports may be adopted as beams and pre-coding matrixes for transmission of k transmission layers respectively.

5) A fifth manner

The pre-coding scheme determination unit 202 may determine the target SRS resource from the at least one SRS resource according to the RI and determine the
25 pre-coding scheme for the uplink data according to the pre-coding scheme for the target SRS resource.

In this manner, the DCI with the RI does not include the indication information of the SRS resource.

The at least one SRS resource includes K SRS resources and k antenna ports
30 are adopted for the k^{th} SRS resource, where N is a number of ports for uplink data transmission and $1 \leq k \leq K$, $K \leq N$.

In this manner, the number of the target SRS resource is 1, the port number for the target SRS resource is the transmission layer number, the RI is used for indicating

both the transmission layer number and the target SRS resource, each target SRS resource corresponds to an uplink transmission layer number, and the beams and pre-coding matrixes for the target SRS resources at the k ports may be adopted as the beams and pre-coding matrixes for transmission of k transmission layers respectively.

5 The pre-coding scheme determination unit 202 may determine the manner for determining the pre-coding scheme for the uplink data according to the indication information of the pre-coding scheme acquired from the network side or the port number for the at least one SRS resource.

10 FIG. 3 is a block diagram of a network-side device embodiment according to the disclosure. As shown in FIG. 3, a network-side device includes a first processing unit 301 and a second processing unit 302.

15 The first processing unit 301 is configured to acquire an SRS transmitted by a terminal device on at least one SRS resource and send DCI for scheduling uplink data transmission to the terminal device. The DCI includes an RI and/or an SRI, and is used for the terminal device to determine a pre-coding scheme for uplink data according to the at least one SRS resource and at least one of the RI and the SRI and pre-code the uplink data according to the pre-coding scheme.

 The second processing unit 302 is configured to receive the pre-coded uplink data sent by the terminal device.

20 The pre-coding scheme includes at least one of: a beam for analogue domain beamforming, and a pre-coding matrix for digital domain pre-coding. The terminal device may also combine analogue beamforming and digital pre-coding to obtain a joint pre-coding matrix as the pre-coding scheme for the uplink data.

25 The DCI does not include information for indicating the pre-coding matrix for the uplink data, and the terminal device may determine the pre-coding scheme for the uplink data according to the RI and/or SRI in the DCI, the at least one SRS resource, channel reciprocity and the like.

 A single antenna port is adopted for each of the at least one SRS resource.

 Or, N antenna ports are adopted for each of the at least one SRS resource.

30 Or, the at least one SRS resource comprises K SRS resources, and k antenna ports are adopted for the k^{th} SRS resource of the K SRS resources.

N is a number of ports for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.

 In addition, a beam for transmitting the SRS may be determined by the

terminal device according to downlink channel information obtained from a downlink signal.

The disclosure also discloses an uplink pre-coding system, which includes the terminal device shown in FIG. 2 and the network-side device shown in FIG. 3.

5 Each embodiment in the abovementioned embodiments is described with different emphases, and undetailed parts in a certain embodiment may refer to related descriptions in the other embodiments.

10 In short, with adoption of the solutions in each embodiment, the terminal device may determine the pre-coding scheme for the uplink data based on RI and/or SRI information of the network side, the at least one SRS resource, the channel reciprocity and the like, so that not only is the signaling overhead of the DCI reduced, but also an uplink pre-coding gain may be increased.

15 In some embodiments provided by the disclosure, it is to be understood that the disclosed device and method and the like may be implemented in another manner. For example, the above-described device embodiment is only schematic. For example, division of the units is only logical function division, and other division manners may be adopted during practical implementation.

20 The units described as separate parts may or may not be physically separated, and parts displayed as units may or may not be physical units, and namely may be located in the same place, or may also be distributed to multiple network units. Part or all of the units may be selected to achieve the purpose of the solutions of the embodiments according to a practical requirement.

25 In addition, each function unit in each embodiment of the disclosure may be integrated into a processing unit, each unit may also exist independently, and two or more than two units may also be integrated into a unit. The integrated unit may be implemented in a hardware form and may also be implemented in form of hardware and software functional unit.

30 The integrated unit implemented in form of software functional unit may be stored in a computer-readable storage medium. The software functional unit is stored in a storage medium, including a plurality of instructions configured to enable a computer device (which may be a personal computer, a server, a network device or the like) or a processor to execute part of the steps of the method in each embodiment of the disclosure. The storage medium includes: various media capable of storing

program codes such as a U disk, a mobile hard disk, a Read-Only Memory (ROM), a Random Access Memory (RAM), a magnetic disk or an optical disk.

The above is only the preferred embodiment of the disclosure and not intended to limit the disclosure. Any modifications, equivalent replacements, improvements
5 and the like made within the spirit and principle of the disclosure shall fall within the scope of protection of the disclosure.

CLAIMS

- 5 1. An uplink pre-coding method, comprising:
- transmitting, by a terminal device, a sounding reference signal (SRS) on at least one SRS resource;
- receiving, by the terminal device, downlink control information (DCI) for scheduling uplink data transmission from a network side, wherein the DCI comprises
- 10 at least one of a rank indication (RI) and an SRS resource indication (SRI);
- determining, by the terminal device, a pre-coding scheme for uplink data according to at least one SRS resource and at least one of the RI and the SRI; and
- pre-coding, by the terminal device, the uplink data according to the pre-coding scheme; and
- 15 sending, by the terminal device, the pre-coded uplink data.
2. The method of claim 1, wherein
- the pre-coding scheme comprises at least one of: a beam for analogue domain beamforming, and a pre-coding matrix for digital domain pre-coding.
- 20 3. The method of claim 1, wherein
- the DCI does not comprise information for indicating the pre-coding matrix for the uplink data.
- 25 4. The method of claim 1, wherein
- a single antenna port is adopted for each of the at least one SRS resource;
- or, N antenna ports are adopted for each of the at least one SRS resource;
- or, the at least one SRS resource comprises K SRS resources, and k antenna ports are adopted for a k^{th} SRS resource of the K SRS resources,
- 30 where N is a number of ports for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.
5. The method of claim 1, wherein
- the terminal device determines a beam for transmitting the SRS according to downlink channel information obtained from a downlink signal.

6. The method of claim 1, wherein

determining, by the terminal device, the pre-coding scheme for the uplink data according to at least one SRS resource and at least one of the RI and the SRI

5 comprises:

determining one or more target SRS resources from the at least one SRS resource according to the RI and the SRI; and

determining the pre-coding scheme for the uplink data according to a pre-coding scheme for the target SRS resource.

10

7. The method of claim 6, wherein

determining the one or more target SRS resources from the at least one SRS resource according to the RI and the SRI comprises:

determining the number of the target SRS resources according to the RI; and

15 determining the target SRS resource according to the number of the target SRSs resource and the SRI.

8. The method of claim 6, wherein

a single antenna port is adopted for each of the at least one SRS resource.

20

9. The method of claim 1, wherein

determining, by the terminal device, the pre-coding scheme for the uplink data according to at least one SRS resource and at least one of the RI and the SRI comprises:

25 determining a transmission layer number according to the RI, and determining the pre-coding matrix for the uplink data according to the transmission layer number and uplink channel information;

determining one or more target SRS resources from the at least one SRS resource according to the SRI, and determining a beam for the uplink data according to a beam for the target SRS resources; and

30 obtaining the pre-coding scheme for the uplink data according to the determined pre-coding matrix and beam.

10. The method of claim 9, wherein

N antenna ports are adopted for each of the at least one SRS resource, where N is a number of ports for uplink data transmission.

5 11. The method of claim 1, wherein

determining, by the terminal device, the pre-coding scheme for the uplink data according to at least one SRS resource and at least one of the RI and the SRI comprises:

10 determining the transmission layer number according to the RI, and determining the pre-coding matrix for the uplink data according to the transmission layer number and the uplink channel information;

determining the beam for the uplink data according to a beam for the at least one SRS resource; and

15 obtaining the pre-coding scheme for the uplink data according to the determined pre-coding matrix and beam.

12. The method of claim 11, wherein

the DCI with the RI does not comprise indication information of the SRS resource.

20

13. The method of claim 11, wherein

N antenna ports are adopted for each of the at least one SRS resource, where N is a number of ports for uplink data transmission.

25 14. The method of claim 11, wherein

the at least one SRS resource comprises one SRS resource.

15. The method of claim 9 or 11,

further comprising:

30 obtaining, by the terminal device, the uplink channel information according to downlink channel information obtained based on a downlink signal.

16. The method of claim 15, wherein

the downlink signal is indicated to the terminal device through a pre-coding matrix indication (PMI) domain in the DCI.

17. The method of claim 15, wherein

5 the downlink signal comprises a downlink reference signal or a downlink synchronization signal.

18. The method of claim 1, wherein

 determining, by the terminal device, the pre-coding scheme for the uplink data
10 according to at least one SRS resource and at least one of the RI and the SRI
comprises:

 determining one or more target SRS resources from the at least one SRS
resource according to the SRI; and

 determining the pre-coding scheme for the uplink data according to the pre-
15 coding scheme for the target SRS resources.

19. The method of claim 18, wherein

 the DCI with the SRI does not comprise indication information of a
transmission layer number.

20

20. The method of claim 18, wherein

 the terminal device determines a transmission layer number according to a
number of ports for the target SRS resources or a number of the target SRS resources.

25 21. The method of claim 1, wherein

 determining, by the terminal device, the pre-coding scheme for the uplink data
according to at least one SRS resource and at least one of the RI and the SRI
comprises:

 determining the target SRS resources from the at least one SRS resource
30 according to the RI; and

 determining the pre-coding scheme for the uplink data according to the pre-
coding scheme for the target SRS resources.

22. The method of claim 21, wherein
the DCI with the RI does not comprise indication information of the SRS resource.
- 5 23. The method of claim 21, wherein
the at least one SRS resource comprises K SRS resources, and k antenna ports are adopted for the k^{th} SRS resource of the K SRS resources,
where N is a number of ports for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.
- 10 24. The method of claim 1,
further comprising:
determining, by the terminal device, a manner for determining the pre-coding scheme for the uplink data according to indication information of the pre-coding scheme acquired from the network side or a number of ports adopted for the at least
15 one SRS resource.
25. The method of claim 1,
further comprising:
determining the pre-coding scheme based on downlink channel information
20 obtained from a downlink signal.
26. An uplink pre-coding method, comprising:
acquiring, by a network-side device, a sounding reference signal (SRS) transmitted by a terminal device on at least one SRS resource;
25 sending, by the network-side device, downlink control information (DCI) for scheduling uplink data transmission to the terminal device, wherein the DCI comprises at least one of a rank indication (RI) and an SRS resource indication (SRI), and is used for the terminal device to determine a pre-coding scheme for uplink data according to the at least one SRS resource and at least one of the RI and the SRI and
30 pre-code the uplink data according to the pre-coding scheme; and
receiving, by the network-side device, the pre-coded uplink data from the terminal device.

27. The method of claim 26, wherein
the pre-coding scheme comprises at least one of: a beam for analogue domain beamforming, and a pre-coding matrix for digital domain pre-coding.

5 28. The method of claim 26, wherein
the DCI does not comprise information for indicating the pre-coding matrix for the uplink data.

29. The method of claim 26, wherein

10 a single antenna port is adopted for each of the at least one SRS resource;
or, N antenna ports are adopted for each of the at least one SRS resource;
or, the at least one SRS resource comprises K SRS resources, and k antenna
ports are adopted for the k^{th} SRS resource of the K SRS resources,
where N is a number of ports for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.

15

30. The method of claim 26, wherein

a beam for transmitting the SRS is determined by the terminal device according to downlink channel information obtained from a downlink signal.

20 31. A terminal device, comprising an information processing unit, a pre-coding scheme determination unit and an uplink data processing unit, wherein

the information processing unit is configured to transmit a sounding reference signal (SRS) on at least one SRS resource and receive downlink control information (DCI) for scheduling uplink data transmission from a network side, wherein the DCI
25 comprises at least one of a rank indication (RI) and an SRS resource indication (SRI);

the pre-coding scheme determination unit is configured to determine a pre-coding scheme for uplink data according to at least one SRS resource and at least one of the RI and the SRI; and

the uplink data processing unit is configured to pre-code the uplink data
30 according to the pre-coding scheme and send the pre-coded uplink data.

32. The terminal device of claim 31, wherein

the pre-coding scheme comprises at least one of: a beam for analogue domain

beamforming, and a pre-coding matrix for digital domain pre-coding.

33. The terminal device of claim 31, wherein

the DCI does not comprise information for indicating the pre-coding matrix
5 for the uplink data.

34. The terminal device of claim 31, wherein

a single antenna port is adopted for each of the at least one SRS resource;
or, N antenna ports are adopted for each of the at least one SRS resource;
10 or, the at least one SRS resource comprises K SRS resources, and k antenna
ports are adopted for the k^{th} SRS resource of the K SRS resources,
where N is a number of ports for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.

35. The terminal device of claim 31, wherein

15 the information processing unit determines a beam for transmitting the SRS
according to downlink channel information obtained from a downlink signal.

36. The terminal device of claim 31, wherein

the pre-coding scheme determination unit is configured to determine one or
20 more target SRS resources from the at least one SRS resource according to the RI and
the SRI, and determine the pre-coding scheme for the uplink data according to a pre-
coding scheme for the target SRS resources.

37. The terminal device of claim 36, wherein

25 the pre-coding scheme determination unit is configured to determine a number
of the target SRS resources according to the RI, and determine the target SRS
resources according to the number of the target SRS resources and the SRI.

38. The terminal device of claim 36, wherein

30 a single antenna port is adopted for each of the at least one SRS resource.

39. The terminal device of claim 31, wherein

the pre-coding scheme determination unit is configured to determine a

transmission layer number according to the RI, determine the pre-coding matrix for the uplink data according to the transmission layer number and uplink channel information, determine one or more target SRS resources from the at least one SRS resource according to the SRI, determine a beam for the uplink data according to a
5 beam for the target SRS resource, and obtain the pre-coding scheme for the uplink data according to the determined pre-coding matrix and beam.

40. The terminal device of claim 39, wherein

10 N antenna ports are adopted for each of the at least one SRS resource, where N is a number of ports for uplink data transmission.

41. The terminal device of claim 31, wherein

the pre-coding scheme determination unit is configured to determine a transmission layer number according to the RI, determine the pre-coding matrix for
15 the uplink data according to the transmission layer number and uplink channel information, determine a beam for uplink data according to a beam for the at least one SRS resource, and obtain the pre-coding scheme for the uplink data according to the determined pre-coding matrix and beam.

20 42. The terminal device of claim 41, wherein

the DCI with the RI does not comprise indication information of the SRS resource.

43. The terminal device of claim 41, wherein

25 N antenna ports are adopted for each of the at least one SRS resource, where N is a number of ports for uplink data transmission.

44. The terminal device of claim 41, wherein

the at least one SRS resource comprises one SRS resource.
30

45. The terminal device of claim 39 or 41, wherein

the pre-coding scheme determination unit is configured to obtain the uplink channel information according to downlink channel information obtained based on a

downlink signal.

46. The terminal device of claim 45, wherein

the downlink signal is indicated to the terminal device through a pre-coding
5 matrix indication (PMI) domain in the DCI.

47. The terminal device of claim 45, wherein

the downlink signal comprises a downlink reference signal or a downlink
synchronization signal.

10

48. The terminal device of claim 31, wherein

the pre-coding scheme determination unit is configured to determine one or
more target SRS resources from the at least one SRS resource according to the RI and
the SRI, and determine the pre-coding scheme for the uplink data according to the
15 pre-coding scheme for the target SRS resources.

49. The terminal device of claim 48, wherein

the DCI with the SRI does not comprise indication information of a
transmission layer number.

20

50. The terminal device of claim 48, wherein

the pre-coding scheme determination unit is configured to determine the
transmission layer number according to a number of ports for the target SRS
resources or a number of the target SRS resources.

25

51. The terminal device of claim 31, wherein

the pre-coding scheme determination unit is configured to determine one or
more target SRS resources from the at least one SRS resource according to the RI, and
determine the pre-coding scheme for the uplink data according to a pre-coding
30 scheme for the target SRS resources.

52. The terminal device of claim 51, wherein

the DCI with the RI does not comprise the indication information of the SRS

resource.

53. The terminal device of claim 51, wherein

the at least one SRS resource comprises K SRS resources, and k antenna ports
5 are adopted for the k^{th} SRS resource of the K SRS resources,
where N is a number of ports for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.

54. The terminal device of claim 31, wherein

the pre-coding scheme determination unit is configured to determine a manner
10 for determining the pre-coding scheme for the uplink data according to indication
information of the pre-coding scheme acquired from the network side or a number of
ports for the at least one SRS resource.

55. The terminal device of claim 31, wherein

15 the pre-coding scheme is determined based on the downlink channel
information obtained from the downlink signal.

56. A network-side device, comprising a first processing unit and a second
processing unit, wherein

20 the first processing unit is configured to acquire a sounding reference signal
(SRS) transmitted by a terminal device on at least one SRS resource, and send
downlink control information (DCI) for scheduling uplink data transmission to the
terminal device, wherein the DCI comprises at least one of a rank indication (RI) and
an SRS resource indication (SRI), for the terminal device to determine a pre-coding
25 scheme for uplink data according to the at least one SRS resource and at least one of
the RI and the SRI and pre-code the uplink data according to the pre-coding scheme;
and

the second processing unit is configured to receive the pre-coded uplink data
sent by the terminal device.

30

57. The network-side device of claim 56, wherein

the pre-coding scheme comprises at least one of: a beam for analogue domain
beamforming, and a pre-coding matrix for digital domain pre-coding.

58. The network-side device of claim 56, wherein
the DCI does not comprise information for indicating the pre-coding matrix
for the uplink data.

5

59. The network-side device of claim 56, wherein
a single antenna port is adopted for each of the at least one SRS resource;
or, N antenna ports are adopted for each of the at least one SRS resource;
or, the at least one SRS resource comprises K SRS resources, and k antenna
10 ports are adopted for the k^{th} SRS resource of the K SRS resources,
where N is a number of ports for uplink data transmission, $1 \leq k \leq K$, $K \leq N$.

60. The network-side device of claim 56, wherein
a beam for transmitting the SRS is determined by the terminal device
15 according to downlink channel information obtained from a downlink signal.

61. An uplink pre-coding system, comprising:
the terminal device of any one of claims 31-55 and the network-side device of
any one of claims 56-60.

20