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(71) Applicant *(for all designated States except US)*: **TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)** [SE/SE]; S-164 83 Stockholm (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HU, Yang** [CN/CN]; Ericsson Tower, No.5 Lize East Street, Chaoyang District, Beijing, 100102 (CN). **SONG, Xinghua** [CN/CN]; Ericsson Tower, No. 5 Lize East Street, Chaoyang District, Beijing, 100102 (CN). **ASTELY, David** [SE/SE]; Stobaeusvägen 22, S-Bromma, 16856 (SE). **JÖNGREN, George** [SE/SE]; Karlsviksgatan 15, S-11241 Stockholm (SE).

(74) Agent: **HASSELGREN, Joakim**; Ericsson AB, Patent Unit LTE, Torshamnsgatan 23, S-164 80 Stockholm (SE).

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(54) Title: TRANSMITTER, RECEIVER AND METHODS FOR DOWNLINK CONTROL SIGNALLING

(57) Abstract: Downlink control information (DCI) extensions to support 3GPP Rel-10 functionalities comprise minimal extensions of DCI format 2B. In some embodiments, only two extra bits (20) are introduced to signal rank up to eight, by reusing the Scrambling Identity bit (16) while at the same time supporting different MU-MIMO dimensioning for the important cases of rank-1 and rank-2. This new DCI format can potentially support not only single cell downlink transmission but also some other Rel-10 functionalities, *e.g.* CoMP or relaying/HetNet.

TRANSMITTER, RECEIVER AND METHODS FOR DOWNLINK CONTROL SIGNALLING

TECHNICAL FIELD

The present invention relates generally to a transmitter, a receiver and methods therein, and in particular to downlink control signaling design for e.g. LTE-Advanced, such as control signaling design for LTE-A downlink transmission mode.

BACKGROUND

The 3rd Generation Partnership Project (3GPP) is responsible for the standardization of UMTS (Universal Mobile Telecommunication Service) and LTE (Long Term Evolution). LTE is a technology for realizing high-speed, packet-based communication that can reach high data rates both in the downlink and in the uplink. LTE is considered a next generation mobile communication system relative to UMTS. In order to support high data rates, LTE allows for a system bandwidth of up to 20 MHz. LTE is also able to operate in different frequency bands and can operate in at least FDD (Frequency Division Duplex) and TDD (Time Division Duplex). The modulation technique or the transmission method used in LTE is known as OFDM (Orthogonal Frequency Division Multiplexing).

For the next generation mobile communications system, *e.g.*, IMT-advanced (International Mobile Telecommunications) and/or LTE-Advanced, which is an evolution of LTE, support for bandwidths of up to 100 MHz is being considered. In both LTE and LTE-Advanced, radio base stations are known as eNBs or eNodeBs, where “e” stands for evolved. Furthermore, multiple antennas with precoding/beamforming technology can be used in order to provide high data rates to user equipments. Thus, LTE and LTE-Advanced are both examples of MIMO (Multiple-Input, Multiple-Output) radio systems. Another example of a MIMO and OFDM based system is WiMAX (Worldwide Interoperability for Microwave Access).

In LTE-Advanced, as specified in 3GPP Release 10 (Rel-10), *e.g.*, Technical Specification 36.814 V1.5.0 (2009-11), in order to fulfill LTE-Advanced downlink peak spectral efficiency of 30bps/Hz, up to eight layer transmission will be supported using advanced 8x8 high-order MIMO. It is also agreed in Rel-10 that up to eight UE-specific reference signals (called demodulation RS or DM-RS) should be introduced for the purpose of channel demodulation. So far, DM-RS rank 1-8 pattern with normal CP (cyclic prefix) has been decided, as shown in Figure 1.

A total of eight DM-RS ports are defined, multiplexed by CDM+FDM (code and frequency division multiplexing). The DM-RS overhead will be the same, *i.e.*, twelve resource elements (RE) per layer. Up to two CDM groups are supported, FDM. Each CDM group has up to four DM-RS ports. DM-RS port numbering is defined as CDM group 1: ports 7/8/11/13; and CDM group 2: ports 9/10/12/14. Orthogonal cover codes (OCC) are defined across the time domain only.

Figure 1 depicts a DM-RS pattern supporting up to rank eight transmission. In the case of Rel-9 dual layer beamforming, *i.e.*, downlink transmission mode eight (TM8), only CDM group 1 (denoted by the numeral "1") is used while the REs reserved for CDM group 2 (denoted by the numeral "2") are used for data transmission.

Downlink Control Information (DCI) format 2B has been defined in 3GPP TS 36.212 v9.0.0 (2009-12), the disclosure of which is incorporated herein by reference in its entirety. DCI format 2B enables dynamic rank adaptation between rank-1 and rank-2, as well as transparent configuration of single-user (SU) case and multi-user (MU) case, where DM-RS ports 7/8 with up to two scrambling sequences are dynamically allocated. Figure 2 depicts a table 10 listing different application cases that are implicitly indicated by some information carried in DCI format 2B. The information is encoded by disabled/enabled transport blocks (TB) 12, a 1-bit new data indicator (NDI) 14, and a 1-bit scrambling identity (SI) 16. These bits encode the information listed in the "Message" column.

SUMMARY

According to one or more embodiments disclosed and claimed herein, minimal extension of DCI format 2B is proposed, to support Rel-10 functionalities, *e.g.* single cell MIMO, CoMP or possibly relaying/HetNet.

In disclosed embodiments, a new DCI format is proposed in Rel-10 to support Rel-10 MIMO transmission. In some embodiments, only two extra bits are introduced in a DCI format otherwise identical to format 2B, to signal rank up to eight, by reusing the SI bit 16 while at the same time supporting different MU-MIMO dimensioning for the important case of rank-1 and rank-2. This new DCI format can potentially support not only single cell downlink transmission, but also some other Rel-10 functionalities, *e.g.* CoMP or relaying/HetNet.

One embodiment relates to a method in a transmitter for indicating to a receiver a number of signaling layers used in a downlink transmission from the transmitter by signaling a message in a DCI format. Transmitted in the DCI format are two bits indicating the number of layers used in the downlink transmission.

Another embodiment relates to a method in a receiver for enabling the receiver to determine the number of layers used in downlink transmission. A message is received in a DCI format comprising two bits indicating the number of layers. The receiver is configured to receive data according to the DCI and the number of layers.

Yet another embodiment relates to a transmitter operative to indicate to a receiver a number of signaling layers used in a downlink transmission from the transmitter. The transmitter includes a signaling circuit operative to signal a message in a DCI format comprising two bits indicating a number of layers in the downlink transmission.

Still another embodiment relates to receiver operative to determine a number of layers used in a downlink transmission. The receiver includes a receiving circuit operative to receive a

message in a DCI format comprising two bits indicating a number of layers. The receiver further includes a configuring circuit operative to configure the receiver to receive data according to the DCI and number of layers.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a functional block diagram of a prior art DM-RS pattern supporting up to rank eight transmission.

Figure 2 is a table depicting the encoding of DCI bits according to prior art DCI format 2B, and application cases signaled.

Figure 3 is a functional block diagram of a transmitter and receiver in a wireless communication network, with the transmitter transmitting DCI bits according to one embodiment of the present invention.

Figure 4 is a table depicting one encoding of DCI bits, and application cases signaled, according to one embodiment of the present invention.

Figure 5 is a table depicting one encoding of DCI bits, and application cases signaled, according to another embodiment of the present invention.

Figure 6 is a table depicting one encoding of DCI bits, and application cases signaled, according to yet another embodiment of the present invention.

Figure 7 is a table depicting one encoding of DCI bits, and application cases signaled, according to still another embodiment of the present invention.

Figure 8 is a flow diagram of a method by a transmitter of indicating to a receiver a number of signaling layers used in a downlink transmission from the transmitter.

Figure 9 is a flow diagram of a method by a receiver of determining the number of layers used in downlink transmission from a transmitter.

DETAILED DESCRIPTION

As mentioned above, Rel-10 will support up to eight layer transmission. TM8 will remain as specified in Rel-9. DCI format 2B has several deficiencies, and consequently a new DCI format will be required for Rel-10. First, to support up to eight layers transmission, rank will need to be indicated to UE for proper data demodulation. DCI format 2B does not specify this directly, but rather implies rank-1 or rank-2 by whether one TB 12 is disabled or not. Second, according to MU-MIMO dimensioning in Rel-10, rank 1-2 is applicable to SU/MU, while rank 3-8 is defined for SU only. This differs from Rel-9 TM8, where SU and MU have the same scope of up to two layers transmission. Third, a new DCI format may be used not only used for single cell MIMO, but also for Coordinated Multipoint (CoMP), or possibly relaying/heterogeneous network (HetNet). A final consideration is that, since Rel-9 TM8 will be a subset of Rel-10 eight layers transmission, DCI format 2B should be re-used as much as possible in the new DCI format.

Various embodiments of the present invention are presented herein, as applied to different applications or considerations. Only part of the payload is depicted herein, to describe the proposed DCI format, *e.g.* 1-bit NDI 14, 1-bit SI 16, disabled/enabled TBs 12, and an additional two bits 20, denoted A and B. Additional bit fields for other purposes can of course also be present.

Figure 3 depicts a transmitter 100, such as in a radio base station, with processing circuits 120 operative to determine number of layers to be used in a downlink transmission (based on channel quality or configuration). When the number of layers, *i.e.* rank value, is determined, the transmitter 100 transmits over a transmitting circuit, Tx, information in a DCI format compatible with 3GPP Rel-10 indicating rank value to a receiver 140, such as in user equipment. In some embodiments, the Rel-10 DCI format is an extension to format 2B, which comprises two bits A, B used to indicate rank value. The receiver 140 receives over a receiving circuit, Rx, the information in the DCI format and from that information, the receiver determines in processing circuits 160 the number of layers used in the transmission.

The transmitter 100 comprises a processing circuit 120 operative to direct a transmitting circuit Tx to transmit a message in a downlink control information (DCI) format, which DCI format comprises two bits (A,B) indicating number of layers, also referred to as transmission rank.

The receiver 140 comprise a receiving circuit Rx configured to receive a message in a DCI format, which format comprises two bits indicating number of layers, and a processing circuit 160 operative to configure the receiver 140 to receive data according to the downlink control information and number of layers.

The mechanisms described herein for enabling signalling between the transmitter 100 and the receiver 140 in the radio communications network may be implemented through one or more processors, such as processing circuits 120 in the transmitter 100 or processing circuits 160 in the receiver 140, together with computer program code for performing the functions of embodiments described herein. The program code mentioned above may also be provided as a computer program product, for instance in the form of a machine-readable data carrier carrying computer program code for performing embodiments of the present invention when loaded into processing circuits 120, 160 in the transmitter 100 or receiver 140, respectively. One such machine-readable data carrier may be in the form of a CD-ROM disc. Of course, other suitable data carriers may include non-volatile memory, magnetic disc, and the like. The computer program code may furthermore be provided as pure program code on a server and downloaded to the transmitter 100 or the receiver 140.

SI for Rank Signaling

The table 18 of Figure 4 depicts that, when both transport blocks 12 are enabled, only rank-1 is SU/MU; ranks 3-8 are SU only. In this case, according to one embodiment, signaling overhead is reduced by using the 1-bit SI 16, along with newly defined bits A,B 20, to implicitly

indicate rank values 3-8 to the UE (since 1-bit SI 16 is not used for SU case). Rank-2 transmission is hybrid SU/MU. In one embodiment, the 1-bit SI 16 is used to separate co-scheduled UEs. In this embodiment, the new two bits 20 value of (0,0) are used to uniquely indicate to the UE the rank value of 2. Figure 4 depicts one representative encoding of the two bits 20 and the 1-bit SI 16; other encodings are within the scope of the present invention.

SI for MU-MIMO dimensioning

Further to the embodiment described above, the new bits 20 can also be efficiently used for rank 1-2 to indicate more complicated SU/MU case for Rel-10 UEs, *e.g.,* indication of DM-RS ports or CDM group. Three SU/MU application cases are considered.

A first case, in which two DM-RS ports are signaled with two scrambling sequences, is depicted in table 22 of Figure 5. Note that the first five rows are the same as DCI format 2B, where 1-bit SI 16 is used to signal ports 7/8 in CDM-1. In this case, the two new bits 20 are not used for rank-1, and are reserved. Figure 5 depicts one representative encoding of the two bits 20 and the 1-bit SI 16 to signal rank 3-8; other encodings are within the scope of the present invention.

A second case, in which four DM-RS ports in two CDM groups are signaled with one scrambling sequence, is depicted in table 24 of Figure 6. In this case, ports 7/8 in CDM-1 and ports 9/10 in CMD-2 are used, where length-2 OCC will be applied. In one embodiment, rank 1/2 messages in the first ten rows may use the 1-bit SI 16 for signaling the ports. In another embodiment, the ports are signaled by exploiting the new bits 20. Because co-scheduled UEs are allocated with orthogonal ports, co-scheduling of Rel-9 and Rel-10 UEs can be enabled, even with the same scrambling sequence. Accordingly, the 1-bit SI 16 is free, and can be used for the signaling of the ports since further separation between co-scheduled UEs is no longer needed. Hence, the use of scrambling sequences is limited. In another embodiment, either the A-bit or B-bit of the new bits 20 can be utilized to do the same thing as the 1-bit SI 16, to release the limitation of scrambling sequences. Figure 6 depicts one representative encoding of the two bits 20 and the 1-bit SI 16; other encodings are within the scope of the present invention.

A third case, in which four DM-RS ports in CDM group one is signaled with one scrambling sequence, is depicted in table 26 of Figure 7. In this case, ports 7/8/11/13 in CDM-1 are used, where length-4 OCC will be applied. In one embodiment, rank 1/2 messages in the first ten rows may use the 1-bit SI 16 for signaling the OCC length. Table 26 is the same as table 24 of Figure 6, but with different explanation of re-using the 1-bit SI 16. In another embodiment, either A-bit or B-bit of the new bits 20 can be utilized to do the same thing as the 1-bit SI 16, to release the limitation of scrambling sequences. Figure 6 depicts one representative encoding of the two bits 20 and the 1-bit SI 16; other encodings are within the scope of the present invention.

Figure 8 depicts a method 200 of transmitting signaling layer information to a receiver by a transmitter in a wireless communication network, such as an eNB. The transmitter determines a number of signaling layers to be used in a downlink transmission (block 210), and then transmits to a receiver a DCI format including two bits 20 indicating the number of layers used in the downlink transmission (block 220). In various embodiments, as described above, the two bits 20 may be jointly encoded with existing DCI format 2B bits, such as the SI 16, to convey various information in addition to the signaling layer information.

Figure 9 depicts a method 300 of receiving signaling layer information by a receiver in a wireless communication network, such as a UE. The receiver receives a message in a DCI format including two bits 20 indicating the number of signaling layers in a downlink transmission (block 310), and then configures the receiver circuit Rx to receive data according to the DCI and the number of layers (block 320). In various embodiments, as described above, the two bits 20 may be jointly encoded with existing DCI format 2B bits, such as the SI 16, to convey various information in addition to the signaling layer information.

Extension to Signaling Other Scenarios

Note that in the above embodiments, in some cases, *e.g.,* rank-1, the two new bits 20 are reserved. In one embodiment, in these cases, the two new bits 20 may be utilized to signal other application scenarios, particularly those that primarily target rank-1. Such scenarios include, by way of example and without limitation, single cell MU-MIMO, CoMP, or relaying/HetNet. The signaling information could communicate to the UE whether the downlink transmission is conducted in one of those scenarios, according to any encodings of the reserved bits, which may be readily devised for particular applications by those of skill in the art, having the benefit of the teachings of the present disclosure.

New DCI formats for Rel-10, based on DCI format 2B and using two new bits 20 to support Rel-10 MIMO transmission, according to embodiments described above, present numerous advantages. First, the rank value of more than two layers – indeed, as many as eight layers – can be implicitly indicated by joint coding using existing 1-bit SI 16 and introducing only two new bits 20. The standard DCI format 2B can be re-used to the greatest extent possible. Second, for the support of different MU-MIMO dimensioning, 1-bit SI 16 can be re-used as much as possible to efficiently save control signaling, while still allowing scrambling indication for the important cases of rank-1 and rank-2. Finally, the proposed Rel-10 DCI format can separate SU and MU applications, and may be used for other possible Rel-10 functionalities in the case of rank-1, *e.g.* CoMP, relaying, and HetNet.

The present invention may, of course, be carried out in other ways than those specifically set forth herein without departing from essential characteristics of the invention. The present embodiments are to be considered in all respects as illustrative and not restrictive, and

all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

CLAIMS

What is claimed is:

1. A method (200) in a transmitter (100) for indicating to a receiver (140) a number of signaling layers used in a downlink transmission from the transmitter (100) by transmitting a message in a downlink control information, DCI, format, comprising:

transmitting (210) in the DCI format two bits (20) indicating the number of layers used in the downlink transmission.

2. The method of claim 1, further comprising indicating in the DCI format a rank value of more than two layers.

3. The method of any of claims 1-2, wherein the DCI format comprises a 1-bit new data indicator, NDI, (14), a 1-bit Scrambling Identity, SI, (16), and disabled/enabled Transport Blocks, TBs, (12).

4. The method of claim 3, wherein rank 3-8 indicates Single User only, and wherein the 1-bit Scrambling Identity 16 and the additional two bits (20) are jointly encoded to implicitly indicate the transmission rank values of 3-8.

5. The method of claim 3, wherein the DCI format is based on DCI format 2B, modified to support 3GPP Rel-10 MIMO transmission, and wherein the modification comprises the addition of the two bits (20) to DCI format 2B.

6. The method of claim 5, wherein the Scrambling Identity (16) is used for different MU-MIMO dimensioning.

7. The method of claim 5 wherein four demodulation reference signal ports in two code division multiplexing groups are signaled with one scrambling sequence.

8. The method of claim 7 wherein ports 7 and 8 in one code division multiplexing group and ports 9 and 10 in another code division multiplexing group are used.

9. The method of claim 8 wherein the ports are signaled using the Scrambling Identity (16) for rank-1 and rank-2 messages.

10. The method of claim 8 wherein the ports are signaled using either or both of the two bits (20).

11. The method of claim 5 wherein four demodulation reference signal ports in one code division multiplexing group are signaled with one scrambling sequence.

12. The method of claim 11 wherein ports 7, 8, 11, and 13 in one code division multiplexing group are used, and wherein a length-4 orthogonal cover code is applied.

13. The method of claim 12 wherein the orthogonal cover code length is signaled using the Scrambling Identity (16) for rank-1 and rank-2 messages

14. The method of claim 12 wherein the orthogonal cover code length is signaled using either or both of the two bits (20).

15. The method of claim 1, wherein the two bits (20) are used for signaling other transmission scenarios.

16. The method of claim 15 wherein the other transmission scenarios are selected from the group consisting of single cell MU-MIMO, CoMP and relaying/HetNet.

17. A method (300) in a receiver (140) for enabling the receiver (140) to determine the number of layers used in downlink transmission, the method comprising:

receiving (310) a message in a downlink control information, DCI, format comprising two bits (20) indicating the number of layers, and

configuring (320) the receiver (140) to receive data according to the DCI and the number of layers.

18. A transmitter (100) operative to indicate to a receiver (140) a number of signaling layers used in a downlink transmission from the transmitter (100), comprising:

a processing circuit (120) operative to direct a transmitting circuit Tx to transmit a message in a downlink control information, DCI, format, which DCI format comprises two bits (20) indicating a number of layers in the downlink transmission.

19. The transmitter (100) of claim 18 wherein the processing circuit 120 is further operative to indicate in the DCI format a rank value of more than two layers.

20. The transmitter (100) of any of claims 18-19 wherein the DCI format comprises a 1-bit new data indicator, NDI, (14), a 1-bit Scrambling Identity, SI, (16), and disabled/enabled Transport Blocks, TBs, (12).

21. The transmitter (100) of claim 20, wherein rank 3-8 indicates Single User only, and wherein the 1-bit Scrambling Identity 16 and the additional two bits (20) are jointly encoded to implicitly indicate the transmission rank values of 3-8.

22. The transmitter (100) of claim 20, wherein the DCI format is based on DCI format 2B, modified to support 3GPP Rel-10 MIMO transmission, and wherein the modification comprises the addition of the two bits (20) to DCI format 2B.

23. The transmitter (100) of claim 22, wherein the Scrambling Identity (16) is used for different MU-MIMO dimensioning.

24. The transmitter (100) of claim 22 wherein four demodulation reference signal ports in two code division multiplexing groups are signaled with one scrambling sequence.

25. The transmitter (100) of claim 24 wherein ports 7 and 8 in one code division multiplexing group and ports 9 and 10 in another code division multiplexing group are used.

26. The transmitter (100) of claim 25 wherein the ports are signaled using the Scrambling Identity (16) for rank-1 and rank-2 messages.

27. The transmitter (100) of claim 25 wherein the ports are signaled using either or both of the two bits (20).

28. The transmitter (100) of claim 22 wherein four demodulation reference signal ports in one code division multiplexing group are signaled with one scrambling sequence.

29. The transmitter (100) of claim 28 wherein ports 7, 8, 11, and 13 in one code division multiplexing group are used, and wherein a length-4 orthogonal cover code is applied.

30. The transmitter (100) of claim 29 wherein the orthogonal cover code length is signaled using the Scrambling Identity (16) for rank-1 and rank-2 messages

31. The transmitter (100) of claim 29 wherein the orthogonal cover code length is signaled using either or both of the two bits (20).

32. The transmitter (100) of claim 18, wherein the two bits (20) are also used for signaling other transmission scenarios.

33. The transmitter (100) of claim 32 wherein the other transmission scenarios are selected from the group consisting of single cell MU-MIMO, CoMP and relaying/HetNet.

34. A receiver (140) operative to determine a number of layers used in a downlink transmission, the receiver comprising:

a receiving circuit Rx operative to receive a message in a downlink control information, DCI, format comprising two bits (20) indicating a number of layers, and

a processing circuit (160) operative to configure the receiver (140) to receive data according to the DCI and number of layers.

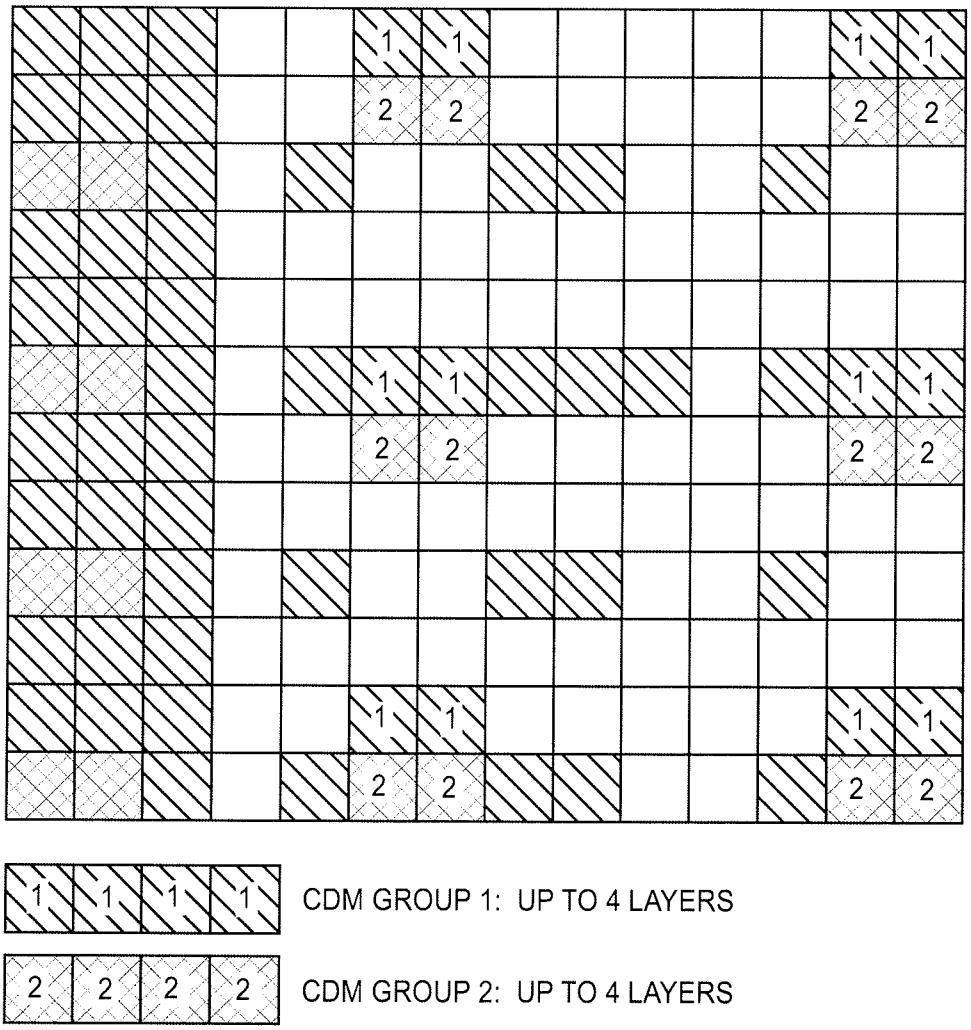


FIG. 1
PRIOR ART

10

12 14 16

TB-1	TB-2	NDI (1-BIT)	SI (1-BIT)	MESSAGE
ENABLE	DISABLE	0 (IN TB-2)	0 OR 1	SU/MU, RANK-1, PORT-7, SCRAMBLING SEQUENCE: 0 OR 1
ENABLE	DISABLE	1 (IN TB-2)	0 OR 1	SU/MU, RANK-1, PORT-8, SCRAMBLING SEQUENCE: 0 OR 1
DISABLE	ENABLE	0 (IN TB-1)	0 OR 1	SU/MU, RANK-1, PORT-7, SCRAMBLING SEQUENCE: 0 OR 1
DISABLE	ENABLE	1 (IN TB-1)	0 OR 1	SU/MU, RANK-1, PORT-8, SCRAMBLING SEQUENCE: 0 OR 1
ENABLE	ENABLE	0 OR 1	0 OR 1	SU/MU, RANK-2, PORTS-7/8, SCRAMBLING SEQUENCE: 0 OR 1

FIG. 2
PRIOR ART

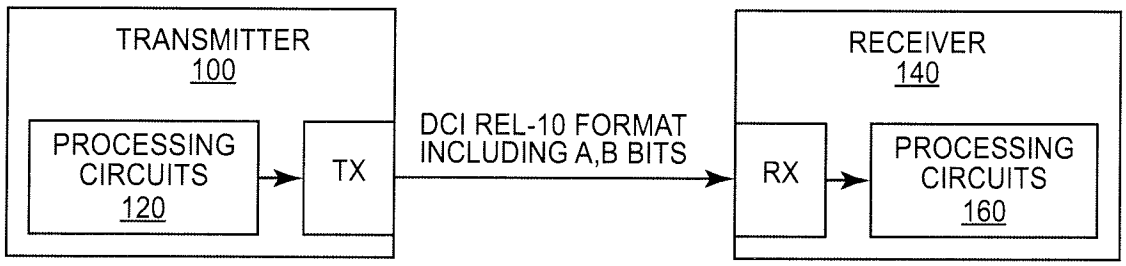
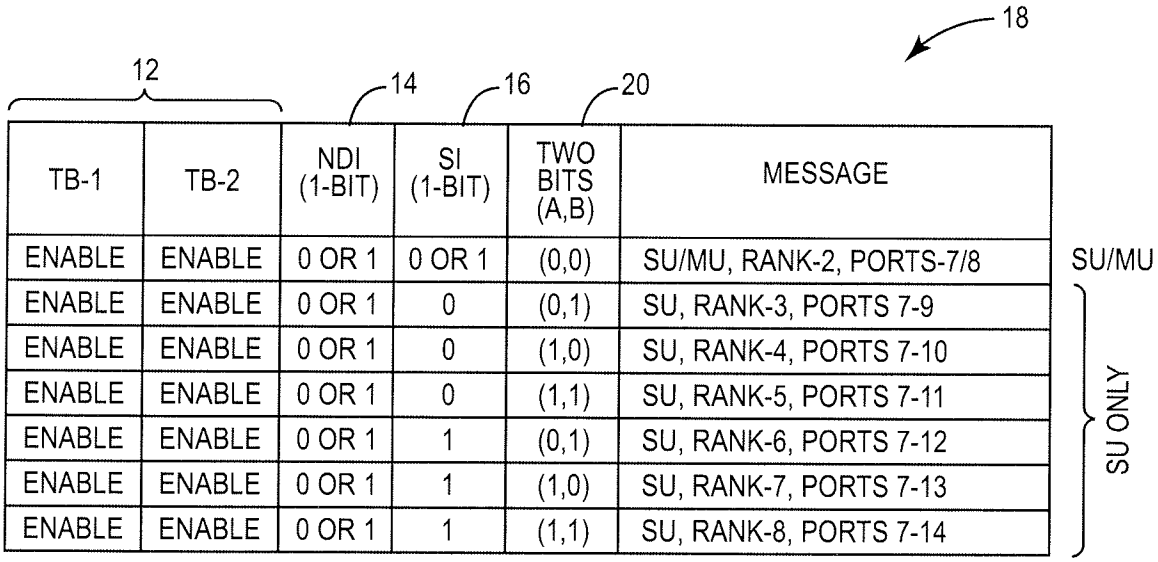
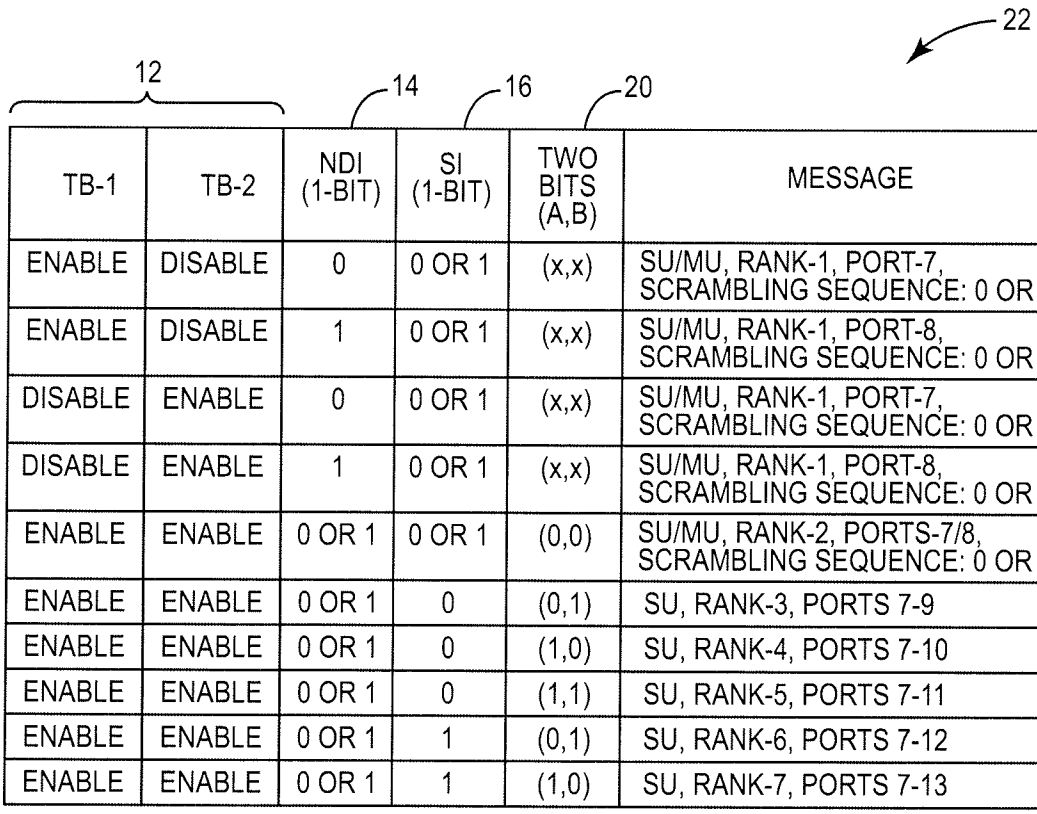

TRANSMITTER
100
PROCESSING CIRCUITS
120
TX
DCI REL-10 FORMAT
INCLUDING A,B BITS
RECEIVER
140
RX
PROCESSING CIRCUITS
160

FIG. 3



TB-1	TB-2	NDI (1-BIT)	SI (1-BIT)	TWO BITS (A,B)	MESSAGE
ENABLE	ENABLE	0 OR 1	0 OR 1	(0,0)	SU/MU, RANK-2, PORTS-7/8
ENABLE	ENABLE	0 OR 1	0	(0,1)	SU, RANK-3, PORTS 7-9
ENABLE	ENABLE	0 OR 1	0	(1,0)	SU, RANK-4, PORTS 7-10
ENABLE	ENABLE	0 OR 1	0	(1,1)	SU, RANK-5, PORTS 7-11
ENABLE	ENABLE	0 OR 1	1	(0,1)	SU, RANK-6, PORTS 7-12
ENABLE	ENABLE	0 OR 1	1	(1,0)	SU, RANK-7, PORTS 7-13
ENABLE	ENABLE	0 OR 1	1	(1,1)	SU, RANK-8, PORTS 7-14

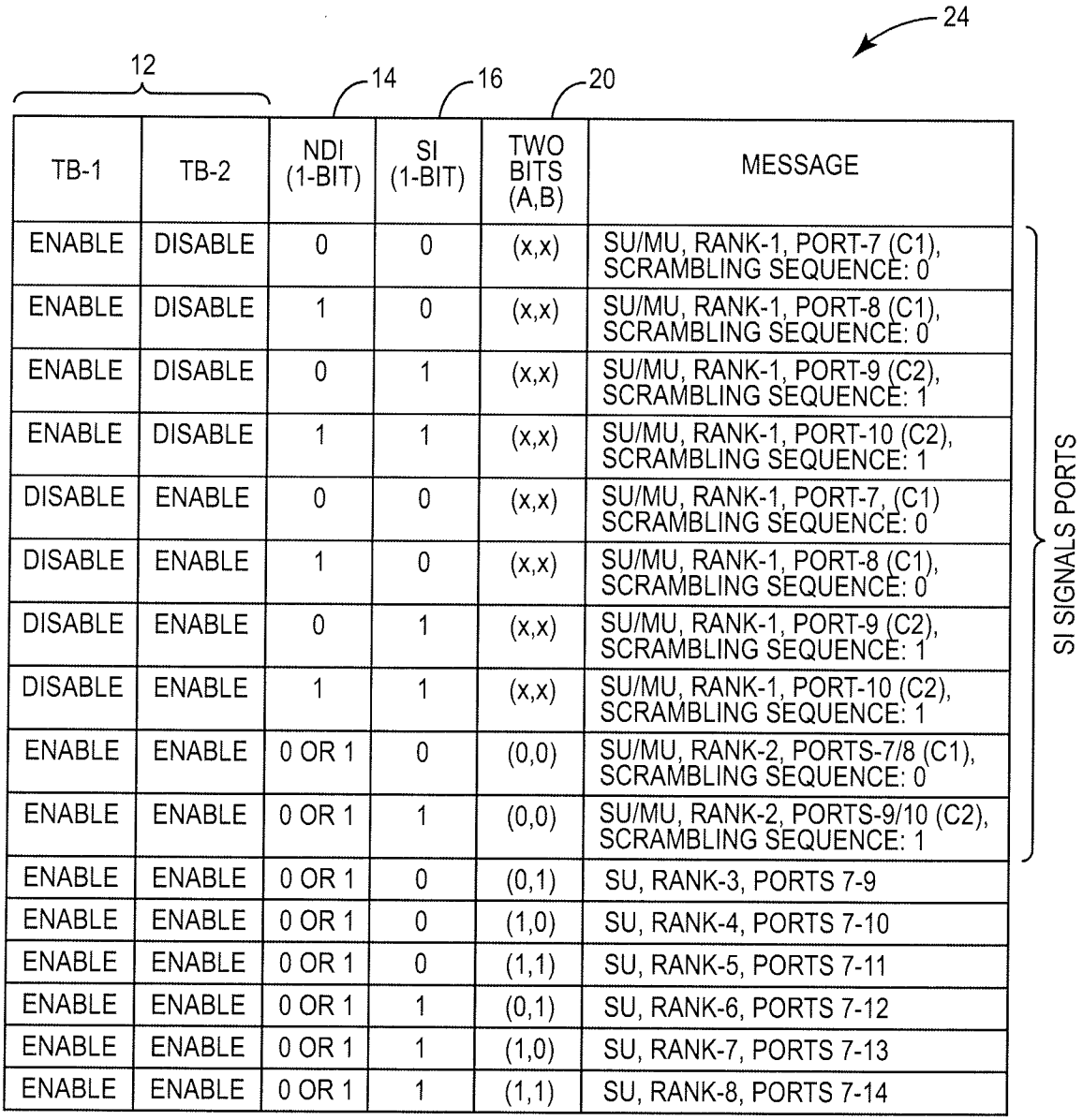
FIG. 4



TB-1	TB-2	NDI (1-BIT)	SI (1-BIT)	TWO BITS (A,B)	MESSAGE
ENABLE	DISABLE	0	0 OR 1	(x,x)	SU/MU, RANK-1, PORT-7, SCRAMBLING SEQUENCE: 0 OR 1
ENABLE	DISABLE	1	0 OR 1	(x,x)	SU/MU, RANK-1, PORT-8, SCRAMBLING SEQUENCE: 0 OR 1
DISABLE	ENABLE	0	0 OR 1	(x,x)	SU/MU, RANK-1, PORT-7, SCRAMBLING SEQUENCE: 0 OR 1
DISABLE	ENABLE	1	0 OR 1	(x,x)	SU/MU, RANK-1, PORT-8, SCRAMBLING SEQUENCE: 0 OR 1
ENABLE	ENABLE	0 OR 1	0 OR 1	(0,0)	SU/MU, RANK-2, PORTS-7/8, SCRAMBLING SEQUENCE: 0 OR 1
ENABLE	ENABLE	0 OR 1	0	(0,1)	SU, RANK-3, PORTS 7-9
ENABLE	ENABLE	0 OR 1	0	(1,0)	SU, RANK-4, PORTS 7-10
ENABLE	ENABLE	0 OR 1	0	(1,1)	SU, RANK-5, PORTS 7-11
ENABLE	ENABLE	0 OR 1	1	(0,1)	SU, RANK-6, PORTS 7-12
ENABLE	ENABLE	0 OR 1	1	(1,0)	SU, RANK-7, PORTS 7-13

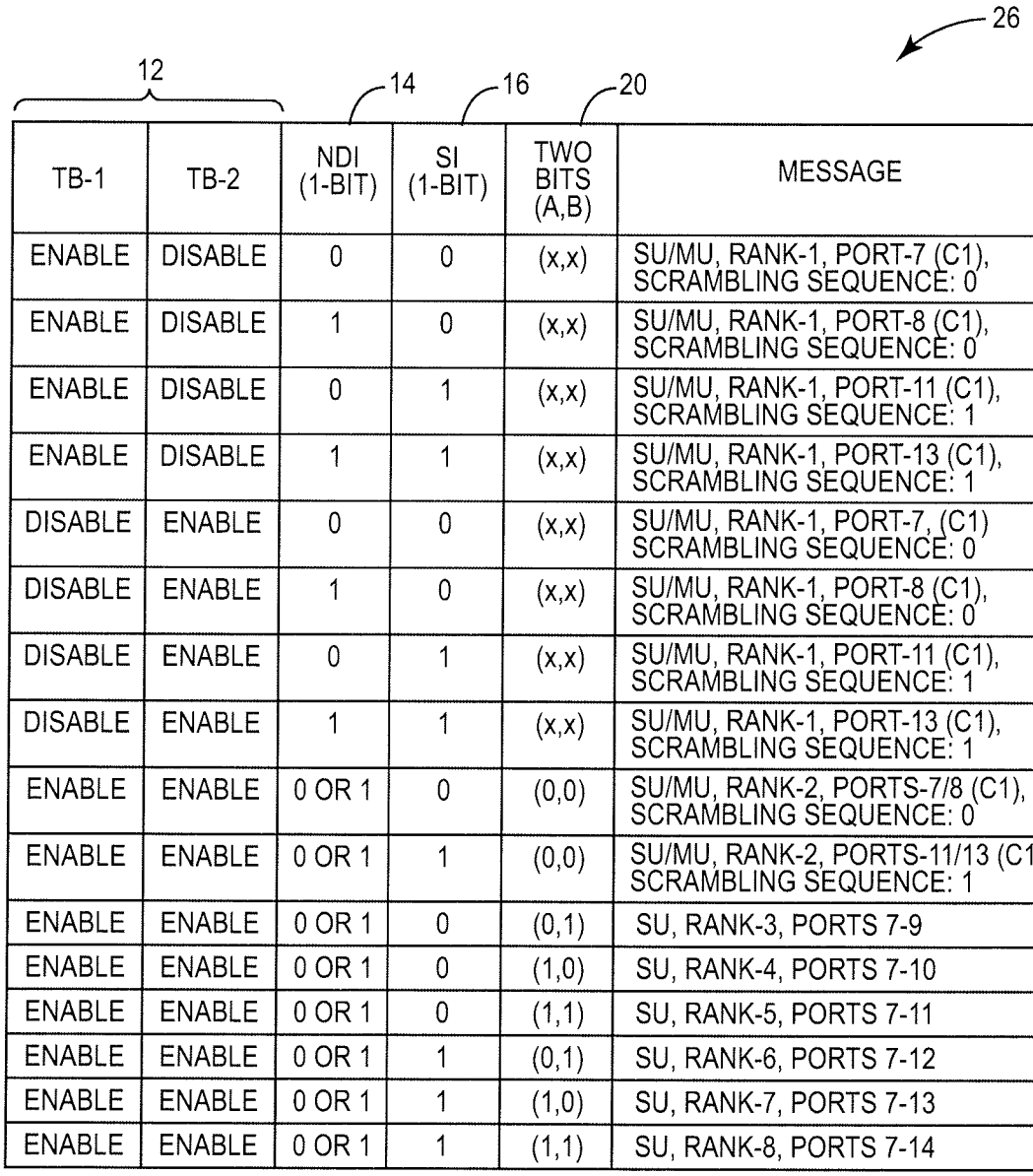
FORMAT 2B

FIG. 5



TB-1	TB-2	NDI (1-BIT)	SI (1-BIT)	TWO BITS (A,B)	MESSAGE
ENABLE	DISABLE	0	0	(x,x)	SU/MU, RANK-1, PORT-7 (C1), SCRAMBLING SEQUENCE: 0
ENABLE	DISABLE	1	0	(x,x)	SU/MU, RANK-1, PORT-8 (C1), SCRAMBLING SEQUENCE: 0
ENABLE	DISABLE	0	1	(x,x)	SU/MU, RANK-1, PORT-9 (C2), SCRAMBLING SEQUENCE: 1
ENABLE	DISABLE	1	1	(x,x)	SU/MU, RANK-1, PORT-10 (C2), SCRAMBLING SEQUENCE: 1
DISABLE	ENABLE	0	0	(x,x)	SU/MU, RANK-1, PORT-7, (C1) SCRAMBLING SEQUENCE: 0
DISABLE	ENABLE	1	0	(x,x)	SU/MU, RANK-1, PORT-8 (C1), SCRAMBLING SEQUENCE: 0
DISABLE	ENABLE	0	1	(x,x)	SU/MU, RANK-1, PORT-9 (C2), SCRAMBLING SEQUENCE: 1
DISABLE	ENABLE	1	1	(x,x)	SU/MU, RANK-1, PORT-10 (C2), SCRAMBLING SEQUENCE: 1
ENABLE	ENABLE	0 OR 1	0	(0,0)	SU/MU, RANK-2, PORTS-7/8 (C1), SCRAMBLING SEQUENCE: 0
ENABLE	ENABLE	0 OR 1	1	(0,0)	SU/MU, RANK-2, PORTS-9/10 (C2), SCRAMBLING SEQUENCE: 1
ENABLE	ENABLE	0 OR 1	0	(0,1)	SU, RANK-3, PORTS 7-9
ENABLE	ENABLE	0 OR 1	0	(1,0)	SU, RANK-4, PORTS 7-10
ENABLE	ENABLE	0 OR 1	0	(1,1)	SU, RANK-5, PORTS 7-11
ENABLE	ENABLE	0 OR 1	1	(0,1)	SU, RANK-6, PORTS 7-12
ENABLE	ENABLE	0 OR 1	1	(1,0)	SU, RANK-7, PORTS 7-13
ENABLE	ENABLE	0 OR 1	1	(1,1)	SU, RANK-8, PORTS 7-14

FIG. 6



TB-1	TB-2	NDI (1-BIT)	SI (1-BIT)	TWO BITS (A,B)	MESSAGE
ENABLE	DISABLE	0	0	(x,x)	SU/MU, RANK-1, PORT-7 (C1), SCRAMBLING SEQUENCE: 0
ENABLE	DISABLE	1	0	(x,x)	SU/MU, RANK-1, PORT-8 (C1), SCRAMBLING SEQUENCE: 0
ENABLE	DISABLE	0	1	(x,x)	SU/MU, RANK-1, PORT-11 (C1), SCRAMBLING SEQUENCE: 1
ENABLE	DISABLE	1	1	(x,x)	SU/MU, RANK-1, PORT-13 (C1), SCRAMBLING SEQUENCE: 1
DISABLE	ENABLE	0	0	(x,x)	SU/MU, RANK-1, PORT-7, (C1) SCRAMBLING SEQUENCE: 0
DISABLE	ENABLE	1	0	(x,x)	SU/MU, RANK-1, PORT-8 (C1), SCRAMBLING SEQUENCE: 0
DISABLE	ENABLE	0	1	(x,x)	SU/MU, RANK-1, PORT-11 (C1), SCRAMBLING SEQUENCE: 1
DISABLE	ENABLE	1	1	(x,x)	SU/MU, RANK-1, PORT-13 (C1), SCRAMBLING SEQUENCE: 1
ENABLE	ENABLE	0 OR 1	0	(0,0)	SU/MU, RANK-2, PORTS-7/8 (C1), SCRAMBLING SEQUENCE: 0
ENABLE	ENABLE	0 OR 1	1	(0,0)	SU/MU, RANK-2, PORTS-11/13 (C1), SCRAMBLING SEQUENCE: 1
ENABLE	ENABLE	0 OR 1	0	(0,1)	SU, RANK-3, PORTS 7-9
ENABLE	ENABLE	0 OR 1	0	(1,0)	SU, RANK-4, PORTS 7-10
ENABLE	ENABLE	0 OR 1	0	(1,1)	SU, RANK-5, PORTS 7-11
ENABLE	ENABLE	0 OR 1	1	(0,1)	SU, RANK-6, PORTS 7-12
ENABLE	ENABLE	0 OR 1	1	(1,0)	SU, RANK-7, PORTS 7-13
ENABLE	ENABLE	0 OR 1	1	(1,1)	SU, RANK-8, PORTS 7-14

FIG. 7

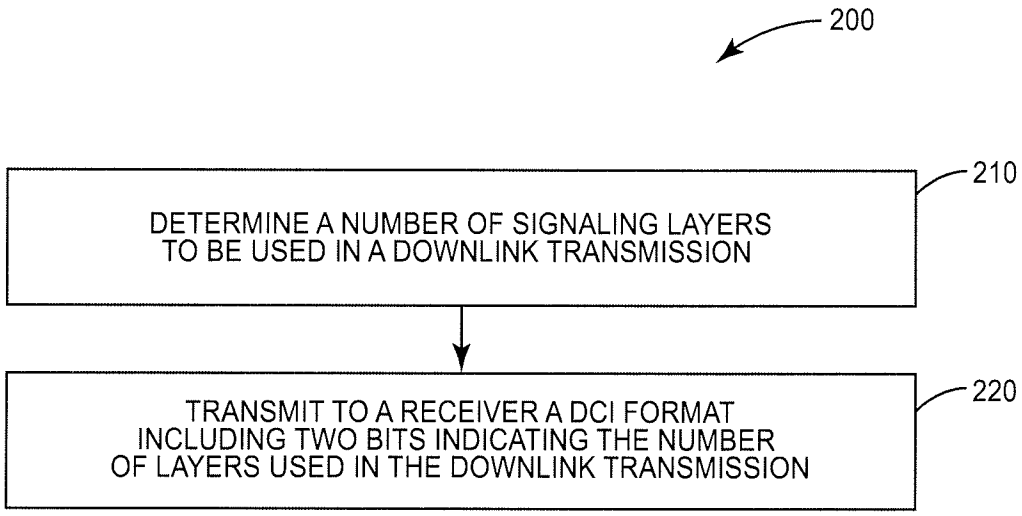

200
DETERMINE A NUMBER OF SIGNALING LAYERS TO BE USED IN A DOWNLINK TRANSMISSION
210
TRANSMIT TO A RECEIVER A DCI FORMAT INCLUDING TWO BITS INDICATING THE NUMBER OF LAYERS USED IN THE DOWNLINK TRANSMISSION
220

FIG. 8

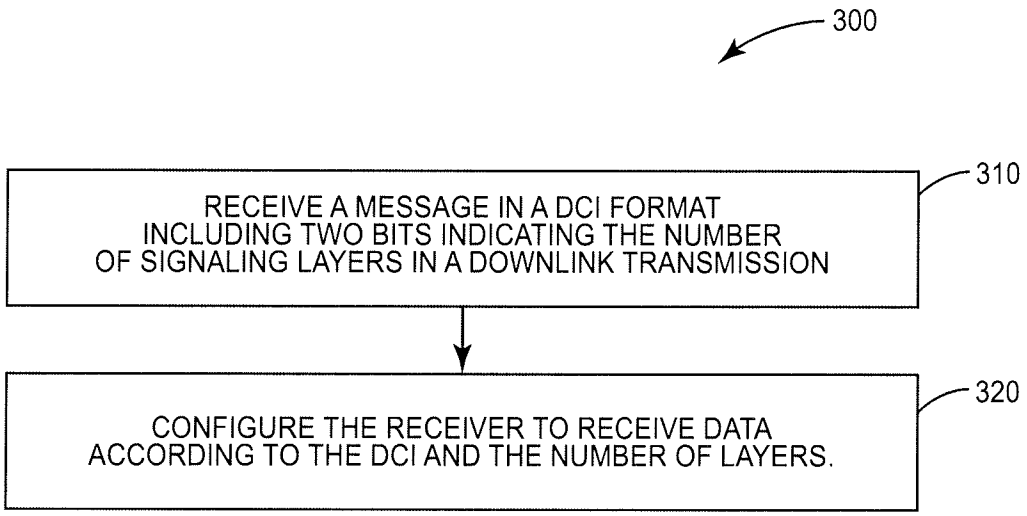

300
RECEIVE A MESSAGE IN A DCI FORMAT INCLUDING TWO BITS INDICATING THE NUMBER OF SIGNALING LAYERS IN A DOWNLINK TRANSMISSION
310
CONFIGURE THE RECEIVER TO RECEIVE DATA ACCORDING TO THE DCI AND THE NUMBER OF LAYERS.
320

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2010/051011

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L25/03 H04L5/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SAMSUNG: "DL transmission modes for Rel-10", 3GPP DRAFT; R1-102208 DLTXMODES, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), vol. RAN WG1, no. Beijing, china; 20100412, 6 April 2010 (2010-04-06), XP050419480, Sect.1, par. 1 Sect. 2, par.s 2-3 ----- -/--	1-34

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2011	07/04/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Colzi, Enrico

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2010/051011

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Anonymous: "DRAFT TS 36.213 V9.1.0; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 9)", 3RD GENERATION PARTNERSHIP PROJECT (3GPP) , 21 March 2010 (2010-03-21), pages 1,27-35, XP002627902, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Specs/archive/36_series/36.213/36213-910.zip [retrieved on 2011-03-18] Sect. 7.1.7	1-34
A	Anonymous: "DRAFT TS 36.212 V9.1.0; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding(Release 9)", 3RD GENERATION PARTNERSHIP PROJECT (3GPP) , 30 March 2010 (2010-03-30), pages 1,55-56, XP002627903, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Specs/archive/36_series/36.212/36212-910.zip [retrieved on 2011-03-18] Sect. 5.3.3.1.5B	1-34
A	EP 2 141 852 A1 (LG ELECTRONICS INC [KR]) 6 January 2010 (2010-01-06) paragraph [0089]	1-34
A	ROBERT LOVE ET AL: "PHY 32-1 - Downlink Control Channel Design for 3GPP LTE", CONFERENCE ON WIRELESS COMMUNICATIONS AND NETWORKING. WCNC 2008, 31 March 2008 (2008-03-31), pages 813-818, XP031243734, IEEE, IEEE, PISCATAWAY, NJ, USA ISBN: 978-1-4244-1997-5 the whole document	1-34

3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/SE2010/051011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2141852 A1	06-01-2010	WO 2010002130 A2	07-01-2010
		US 2010002630 A1	07-01-2010