# CHANNEL STATE INFORMATION REPORTING

## RELATED APPLICATION

**[0001]** This application claims priority to U.S. Provisional Application Serial No. 63/551,593 filed February 9, 2024, entitled "CHANNEL STATE INFORMATION REPORTING," the disclosure of which is incorporated by reference herein in its entirety.

## TECHNICAL FIELD

**[0002]** The present disclosure relates to wireless communications, and more specifically to channel measurement and reporting.

## BACKGROUND

**[0003]** A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communications system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers, or the like)). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

## SUMMARY

**[0004]** An article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also,

as used herein, the phrase “based on” may not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” may be construed in the same manner as the phrase “based at least in part on.” Further, as used herein, including in the claims, a “set” may include one or more elements.

**[0005]** Some implementations of the method and apparatuses described herein may further include a UE for wireless communication to receive a first signaling configuring a channel state information-reference signal (CSI-RS), the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, receive a second signaling configuring a channel state information (CSI) report associated with the CSI-RS, selectively perform at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band based on the first signaling and the second signaling, and transmit a third signaling including the CSI report based on the second signaling.

**[0006]** In some implementations of the method and apparatuses described herein, the UE receives a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the CSI-RS. Additionally, or alternatively, to selectively perform the at least one measurement, the UE performs the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is valid, and where the CSI report includes the at least one measurement. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands satisfying a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands being separated from a sub-band full duplex (SBFD) uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands being compatible with a capability of the UE. Additionally, or alternatively, to selectively perform the at least one measurement, the UE refrains from performing the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is invalid, and where the CSI report includes an indication that the subset of frequency sub-bands is invalid. Additionally, or alternatively, the determination is based on at least one of the subset of frequency

sub-bands failing to satisfy a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands not being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands not being compatible with a capability of the UE.

**[0007]** Additionally, or alternatively, the UE receives a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the CSI-RS, and selectively performs at least one additional measurement on the additional subset of frequency sub-bands based on the first signaling, the second signaling, and a determination that the at least one additional measurement is valid. Additionally, or alternatively, the determination that the additional subset of frequency sub-bands is valid is based on at least one of the additional subset of frequency sub-bands satisfying a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one additional measurement on the additional subset of frequency sub-bands being compatible with a capability of the UE. Additionally, or alternatively, the UE combines the at least one measurement and the at least one additional measurement based on the at least one measurement being associated with a same antenna panel as the at least one additional measurement.

**[0008]** Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of physical resource blocks (PRBs) per sub-band of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation, and where the UE determines the set of frequency sub-bands within the CSI-RS

frequency band based on the semi-static frequency resource allocation and the frequency resources allocation associated with the CSI-RS frequency band. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0009]** Additionally, or alternatively, to selectively perform the at least one measurement, the UE performs the at least one measurement for a time period, for a threshold numerical quantity of measurements, for a threshold numerical quantity of measurement occasions, based on a start time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, based on an end time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, or any combination thereof. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement.

**[0010]** Additionally, or alternatively, the UE receives a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the UE transmits a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the UE, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a

maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the UE. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more resource block groups (RBGs).

**[0011]** Some implementations of the method and apparatuses described herein may further include a processor for wireless communication to receive a first signaling configuring a CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, receive a second signaling configuring a CSI report associated with the CSI-RS, selectively perform at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band based on the first signaling and the second signaling, and transmit a third signaling including the CSI report based on the second signaling.

**[0012]** In some implementations of the method and apparatuses described herein, the processor receives a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the CSI-RS. Additionally, or alternatively, to selectively perform the at least one measurement, the processor performs the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is valid, and where the CSI report includes the at least one measurement. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands satisfying a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands being compatible with a capability of the processor. Additionally, or alternatively, to selectively perform the at least one measurement, the processor refrains from performing the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is invalid, and where the CSI report includes an indication that the subset of frequency sub-bands is invalid. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands failing to satisfy a minimum bandwidth for the at least one measurement, respective sub-

bands in the subset of frequency sub-bands not being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands not being compatible with a capability of the processor.

**[0013]** Additionally, or alternatively, the processor receives a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the CSI-RS, and selectively performs at least one additional measurement on the additional subset of frequency sub-bands based on the first signaling, the second signaling, and a determination that the at least one additional measurement is valid. Additionally, or alternatively, the determination that the additional subset of frequency sub-bands is valid is based on at least one of the additional subset of frequency sub-bands satisfying a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one additional measurement on the additional subset of frequency sub-bands being compatible with a capability of the processor. Additionally, or alternatively, the processor combines the at least one measurement and the at least one additional measurement based on the at least one measurement being associated with a same antenna panel as the at least one additional measurement. Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band.

**[0014]** Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation, and where the processor determines the set of frequency sub-bands within the CSI-RS frequency band based on the semi-static frequency resource allocation and the frequency

resources allocation associated with the CSI-RS frequency band. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band. Additionally, or alternatively, to selectively perform the at least one measurement, the processor performs the at least one measurement for a time period, for a threshold numerical quantity of measurements, for a threshold numerical quantity of measurement occasions, based on a start time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, based on an end time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, or any combination thereof.

**[0015]** Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement. Additionally, or alternatively, the processor receives a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0016]** Additionally, or alternatively, the processor transmits a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the processor, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a

respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the processor. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

**[0017]** Some implementations of the method and apparatuses described herein may further include a method performed by a UE, the method including receiving a first signaling configuring a CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, receiving a second signaling configuring a CSI report associated with the CSI-RS, selectively performing at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band based on the first signaling and the second signaling, and transmitting a third signaling including the CSI report based on the second signaling.

**[0018]** In some implementations of the method and apparatuses described herein, the method further includes receiving a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the CSI-RS. Additionally, or alternatively, selectively performing the at least one measurement includes performing the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is valid, and where the CSI report includes the at least one measurement. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands satisfying a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands being compatible with a capability of the UE. Additionally, or alternatively, selectively performing the at least one measurement includes refraining from performing the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is invalid, and where the CSI report includes an indication that the subset of frequency sub-bands is invalid. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands failing to satisfy a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands not being separated from an SBFD

uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands not being compatible with a capability of the UE.

**[0019]** Additionally, or alternatively, the method further includes receiving a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the CSI-RS, and selectively performing at least one additional measurement on the additional subset of frequency sub-bands based on the first signaling, the second signaling, and a determination that the at least one additional measurement is valid. Additionally, or alternatively, the determination that the additional subset of frequency sub-bands is valid is based on at least one of the additional subset of frequency sub-bands satisfying a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one additional measurement on the additional subset of frequency sub-bands being compatible with a capability of the UE. Additionally, or alternatively, the method further includes combining the at least one measurement and the at least one additional measurement based on the at least one measurement being associated with a same antenna panel as the at least one additional measurement.

**[0020]** Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation, and further including determine the set of frequency sub-bands within the CSI-RS frequency band based on the semi-static frequency resource allocation and the frequency resources allocation associated with the CSI-RS frequency

band. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0021]** Additionally, or alternatively, selectively performing the at least one measurement includes performing the at least one measurement for a time period, for a threshold numerical quantity of measurements, for a threshold numerical quantity of measurement occasions, based on a start time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, based on an end time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, or any combination thereof. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement.

**[0022]** Additionally, or alternatively, the method further includes receiving a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the method further includes transmitting a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the UE, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-

band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the UE. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

**[0023]** Some implementations of the method and apparatuses described herein may further include a base station (e.g., a network equipment (NE)) for wireless communication to transmit, to a UE, a first signaling configuring at least one CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, transmit, to the UE, a second signaling configuring a CSI report associated with the at least one CSI-RS, transmit the at least one CSI-RS based on the first signaling, and receive a third signaling including the CSI report based on the second signaling, the CSI report is based on at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0024]** In some implementations of the method and apparatuses described herein, the base station transmits a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the at least one CSI-RS. Additionally, or alternatively, the subset of frequency sub-bands satisfies a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands are separated from an SBFD uplink sub-band by a minimum guard band, the at least one measurement on the subset of frequency sub-bands is compatible with a capability of the UE, or any combination thereof.

**[0025]** Additionally, or alternatively, the at least one processor is configured to cause the base station to transmit a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the at least one CSI-RS, and where the additional subset of frequency sub-bands corresponds to at least one additional measurement on the additional subset of frequency sub-bands. Additionally, or alternatively, the additional subset of frequency sub-bands satisfies a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands are separated from an SBFD uplink sub-band by a minimum guard band, the at least one additional measurement on the additional subset of frequency sub-bands is compatible with a capability of the UE, or any combination thereof. Additionally, or alternatively, the first signaling includes at least one

parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band.

**[0026]** Additionally, or alternatively, the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0027]** Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement. Additionally, or alternatively, the base station transmits a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0028]** Additionally, or alternatively, the base station receives a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the UE, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the UE. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

**[0029]** Some implementations of the method and apparatuses described herein may further include a method performed by a base station, the method including transmitting, to a UE, a first signaling configuring at least one CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, transmitting, to the UE, a second signaling configuring a CSI report associated with the at least one CSI-RS, transmitting the at least one CSI-RS based on the first signaling, and receiving a third signaling including the CSI report based on the second signaling, the CSI report is based on at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0030]** In some implementations of the method and apparatuses described herein, the method further includes transmitting a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the at least one CSI-RS. Additionally, or alternatively, the subset of frequency sub-bands satisfies a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands are separated from an SBFD uplink sub-band by a minimum guard band, the at least one measurement on the subset of frequency sub-bands is compatible with a capability of the UE, or any combination thereof. Additionally, or alternatively, the method further includes transmitting a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the at least one CSI-RS, and where the additional subset of frequency sub-bands corresponds to at least one additional measurement on the additional subset

of frequency sub-bands. Additionally, or alternatively, the additional subset of frequency sub-bands satisfies a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands are separated from an SBFD uplink sub-band by a minimum guard band, the at least one additional measurement on the additional subset of frequency sub-bands is compatible with a capability of the UE, or any combination thereof.

**[0031]** Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0032]** Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement

technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement. Additionally, or alternatively, the method further includes transmitting a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the method further includes receiving a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the UE, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the UE. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0033]** Figures 1 and 2 illustrate example wireless communications systems in accordance with aspects of the present disclosure.

**[0034]** Figures 3 and 4 illustrate example resource diagrams, in accordance with aspects of the present disclosure.

**[0035]** Figures 5 through 7 illustrate example configuration diagrams, in accordance with aspects of the present disclosure.

**[0036]** Figures 8 and 9 illustrate example resource diagrams, in accordance with aspects of the present disclosure.

**[0037]** Figure 10 illustrates an example of a configuration diagram, in accordance with aspects of the present disclosure.

**[0038]** Figure 11 illustrates an example of a resource diagram, in accordance with aspects of the present disclosure.

**[0039]** Figures 12 and 13 illustrate example configuration diagrams, in accordance with aspects of the present disclosure.

**[0040]** Figure 14 illustrates an example of a signaling diagram, in accordance with aspects of the present disclosure.

**[0041]** Figure 15 illustrates an example of a UE in accordance with aspects of the present disclosure.

**[0042]** Figure 16 illustrates an example of a processor in accordance with aspects of the present disclosure.

**[0043]** Figure 17 illustrates an example of an NE in accordance with aspects of the present disclosure.

**[0044]** Figure 18 illustrates a flowchart of a method performed by a UE in accordance with aspects of the present disclosure.

**[0045]** Figure 19 illustrates a flowchart of a method performed by an NE in accordance with aspects of the present disclosure.

## DETAILED DESCRIPTION

**[0046]** A wireless communications system includes one or more devices, such as UEs and NEs, that transmit or receive signaling. For example, a UE may establish a wireless connection with an NE for transmitting and/or receiving control signaling, data signaling, or both. In some examples, the UE may receive one or more reference signals, such as CSI-RSs, from an NE and/or from other devices in the wireless communications system. A CSI-RS may be a reference signal designed to facilitate estimation of CSI at a receiving device (e.g., the UE). The UE may measure one or more characteristics of the CSI-RS, including, but not limited to, a received signal strength (RSSI), a channel quality indicator (CQI), a reference signal received power (RSRP), or a reference signal received quality (RSRQ). The UE may transmit a CSI report to an NE indicating the one or more measurements, among other information. The NE may adjust one or more transmission parameters

for signaling to and from the UE using the information included in the CSI report (a signal strength, a modulation and coding scheme (MCS), a selected beam, resource allocation, etc.).

**[0047]** A UE and an NE can transmit or receive signaling using communication resources. For example, the UE and/or the NE may split (e.g., allocate, distribute) communication resources between uplink transmissions and downlink transmissions in the time domain, which may be referred to as a time division duplexing (TDD) communication scheme. In the TDD communication scheme, transmission and reception of signals occur at different times within a same frequency band, which is described in further detail with respect to Figure 3. Different time resources within a transmission frame, which may be referred to as time slots and may be further divided into symbols, may be allocated to uplink and/or downlink transmissions. Additionally, or alternatively, to reduce latency and provide for greater signaling throughput, the NE and/or the UE may implement SBFD operation. SBFD operation provides for a frequency band to be split into sub-bands for concurrent transmission and reception within a same time slot or using the same symbols, which is described in further detail with respect to Figure 4. For example, a device (e.g., an NE and/or UE) may receive signaling from one or more other devices using a sub-band of a frequency band, while the device concurrently (e.g., within a same duration of symbols or within a same slot) transmits signaling to another device using a different sub-band of the frequency band.

**[0048]** An NE may transmit signaling that indicates a frequency domain location of one or more sub-bands allocated for SBFD communications, such that the frequency domain locations are periodic or aperiodic for a defined duration (e.g., semi-statically configured). The NE may include one or more resources allocated for respective CSI-RS transmissions and/or a CSI report in the signaling, such that the CSI-RS resource allocation may be contiguous in the frequency domain. However, if the NE dynamically allocates the frequency domain locations of one or more sub-bands allocated for SBFD communications (e.g., independent of or without a periodicity), then the resources allocated for CSI-RS transmission and CSI reporting may overlap with the one or more sub-bands allocated for SBFD communications. The overlap in the sub-bands allocated for SBFD communications and resources (e.g., in the frequency domain) allocated for CSI-RS transmission and CSI reporting may lead to communication errors and/or communication delays due to failing to perform one or more CSI-RS measurements and/or CSI reporting, as well as increased signaling

overhead and/or increased use of communication resources due to retransmissions of the CSI-RS caused by failing to perform a CSI-RS measurement and/or CSI reporting.

**[0049]** As described herein, to reduce, or eliminate, overlap of sub-bands allocated for SBFD communications and resources allocated for CSI-RS transmission and CSI reporting an NE may transmit signaling to UE that indicates one or more sub-bands within a CSI-RS frequency band allocated for transmission of a CSI-RS. The NE may transmit additional signaling to the UE configuring a CSI report. For example, the additional signaling may indicate for the CSI report to include a measurement of a CSI-RS, an indication that the measurement is obtained by measuring an SBFD time resource or a non-SBFD time resource, an indication of a subset of frequency sub-bands, and/or an indication of an error status of the measurement. Additionally, or alternatively, the additional signaling may indicate for the CSI report to include one or more measured CSI values, an error status of one or more monitoring occasions that include a CSI-RS, an indication of one or more frequency resources for the measured CSI values, and/or a measurement technique for obtaining the CSI values. In some examples, the NE and/or another device may transmit one or more CSI-RSs to the UE using the indicated sub-bands within the CSI-RS frequency band. The UE may selectively measure the CSI-RSs according to a criteria, which is described in further detail with respect to Figure 2 and may transmit a CSI report to the NE according to the additional signaling.

**[0050]** Aspects of the present disclosure are described in the context of a wireless communications system.

**[0051]** **Figure 1** illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX),

IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

**[0052]** The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communications link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

**[0053]** An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 102 and a UE 104 may support wireless communication of signals related to services (voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

**[0054]** The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

**[0055]** A UE 104 may be able to support wireless communication directly with other UEs 104 over a communications link. For example, a UE 104 may support wireless communication directly

with another UE 104 over a device-to-device (D2D) communications link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communications link may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

**[0056]** An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N6, or other network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other indirectly (e.g., via the CN 106). In some implementations, one or more NE 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

**[0057]** The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a packet data network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NE 102 associated with the CN 106.

**[0058]** The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N6, or other network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server using the established session

(e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

**[0059]** In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

**[0060]** One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu$=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu$=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu$=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu$=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu$=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu$=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

**[0061]** A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

**[0062]** Additionally, or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu$=0, $\mu$=1, $\mu$=2, $\mu$=3, $\mu$=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively.#Each slot may include a number (e.g., quantity) of symbols (e.g., orthogonal frequency division multiplexing (OFDM) symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu$=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

**[0063]** In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

**[0064]** FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu$=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu$=1), which includes 30 kHz

subcarrier spacing; and a third numerology (e.g., $\mu$=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu$=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu$=3), which includes 120 kHz subcarrier spacing.

**[0065]** In some examples, the terms antenna, panel, and antenna panel are used interchangeably. An antenna panel may be hardware that is used for transmitting and/or receiving radio signals at frequencies lower than 6 GHz (e.g., FR1), or higher than 6 GHz (e.g., FR2 or millimeter wave (mmWave)). In some examples, an antenna panel may include an array of antenna elements, where an antenna element is connected to hardware, such as a phase shifter that provides for a control module to apply spatial parameters for transmission and/or reception of signals. The resulting radiation pattern may be called a beam, which may, or may not, be unimodal and may provide for the device (e.g., UE 104, node) to amplify signals that are transmitted or received from one or more spatial directions.

**[0066]** In some examples, an antenna panel may, or may not, be virtualized as an antenna port. An antenna panel may be connected to a baseband processing module through a radio frequency (RF) chain for each of transmission (e.g., egress) and reception (e.g., ingress) directions. A capability of a device in terms of the number of antenna panels, a duplexing capability of the device, beamforming capabilities of the device, and so on, may, or may not, be transparent to other devices. In some examples, capability information may be communicated via signaling, or, in some examples, capability information may be provided to devices without signaling. In the case that such information is available to other devices, such as a CU, the information can be used for signaling or local decision making.

**[0067]** In some examples, an antenna panel may be a physical or logical antenna array including a set of antenna elements or antenna ports that share a common or a significant portion of an RF chain (e.g., in-phase/quadrature (I/Q) modulator, analog to digital (A/D) converter, local oscillator, phase shift network). The antenna panel may be a logical entity with physical antennas mapped to the logical entity. The mapping of physical antennas to the logical entity may be up to implementation. Communicating (e.g., receiving or transmitting) on at least a subset of antenna elements or antenna ports active for radiating energy, also referred to herein as active elements, of

an antenna panel includes biasing or powering on of the RF chain which results in current drain or power consumption at the device (e.g., node) associated with the antenna panel (e.g., including power amplifier/low noise amplifier (LNA) power consumption associated with the antenna elements or antenna ports). The phrase "active for radiating energy," as used herein, is not meant to be limited to a transmit function, but also encompasses a receive function. Accordingly, an antenna element that is active for radiating energy may be coupled to a transmitter to transmit RF energy or to a receiver to receive RF energy, either simultaneously or sequentially, or may be coupled to a transceiver in general, for performing intended functionality. Communicating on the active elements of an antenna panel enables generation of radiation patterns or beams.

**[0068]** In some examples, depending on implementation, a "panel" can have at least one of the following functionalities as an operational role of Unit of antenna group to control a transmit beam independently, Unit of antenna group to control a transmission power independently, Unit of antenna group to control a transmission timing independently. The "panel" may be transparent to another node (e.g., next hop neighbor node). For one or more conditions, another node or network entity can assume the mapping between device's physical antennas to the logical entity "panel" may not be changed. For example, the condition may include until the next update or report from device or include a duration of time over which the NE 102 assumes there will be no change to the mapping. A device may report a device capability with respect to the "panel" to the NE 102. The device capability may include at least the number of "panels." In some implementations, the device may support transmission from one beam within a panel. In some cases, with multiple panels, more than one beam (e.g., one beam per panel) may be used for transmission. In some other implementations, more than one beam per panel may be supported and/or used for transmission.

**[0069]** In some examples, an antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed. Two antenna ports are said to be quasi co-located (QCL) if the large-scale properties of the channel over which a symbol on one antenna port is conveyed can be inferred from the channel over which a symbol on the other antenna port is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, average delay, and spatial receive parameters. Two antenna ports may be quasi-located with respect to a subset of the large-scale properties and different subset of large-scale properties may be

indicated by a QCL type. The QCL type can indicate which channel properties are the same between the two reference signals (e.g., on the two antenna ports). Thus, the reference signals can be linked to each other with respect to what the device can assume about their channel statistics or QCL properties. For example, QCL type may take one of the following values. Other QCL types may be defined based on combination of one or large-scale properties, including, but not limited to, QCL-TypeA, QCL-TypeB, QCL-TypeC, and QCL-TypeD. QCL-TypeA may include a Doppler shift, Doppler spread, average delay, and/or delay spread. QCL-TypeB may include Doppler shift and/or Doppler spread. QCL-TypeC may include Doppler shift and/or average delay. QCL-TypeD may include Spatial receive or reception parameters. Spatial receive or reception parameters may include one or more of an angle of arrival (AoA,) Dominant AoA, average AoA, angular spread, Power Angular Spectrum (PAS) of AoA, average angle of departure (AoD), PAS of AoD, transmit/receive channel correlation, transmit/receive beamforming, spatial channel correlation etc. The QCL-TypeA, QCL-TypeB and QCL-TypeC may be applicable for carrier frequencies, but the QCL-TypeD may be applicable in higher carrier frequencies (e.g., mmWave, FR2 and beyond), where the device may not be able to perform omni-directional transmission (e.g., the device would form beams for directional transmission). A QCL-TypeD between two reference signals A and B, the reference signal A is considered to be spatially co-located with reference signal B and the device may determine that the reference signals A and B can be received with the same spatial filter (e.g., with the same receive beamforming weights).

**[0070]** An “antenna port” may be a logical port that may correspond to a beam (resulting from beamforming) or may correspond to a physical antenna on a device. In some examples, a physical antenna may map directly to a single antenna port, in which an antenna port corresponds to a physical antenna. Additionally, or alternatively, a set or subset of physical antennas, or antenna set or antenna array or antenna sub-array, may be mapped to one or more antenna ports after applying complex weights, a cyclic delay, or both to the signal on each physical antenna. The physical antenna set may have antennas from a single module or panel or from multiple modules or panels. The weights may be fixed as in an antenna virtualization scheme, such as cyclic delay diversity (CDD). The procedure used to derive antenna ports from physical antennas may be specific to a device implementation and transparent to other devices.

**[0071]** In some cases, a transmission configuration indicator (TCI) state associated with a target transmission can indicate parameters for configuring a QCL relationship between the target transmission (e.g., target reference signal of demodulation reference signal (DMRS) ports of the target transmission during a transmission occasion) and one or more source reference signals (e.g., synchronization signal block (SSB), CSI-RS, and/or sounding reference signal (SRS)) with respect to QCL type parameters indicated in the corresponding TCI state. The TCI describes which reference signals are used as QCL source, and what QCL properties can be derived from each reference signal. A device can receive a configuration of a set of TCI states for a serving cell for transmissions on the serving cell (e.g., between a serving gNB and a smart repeater). In some examples, a TCI state includes at least one source reference signal to provide a reference for determining QCL and/or spatial filter.

**[0072]** In some cases, an uplink TCI state is provided if a device is configured with separate downlink and/or uplink TCI by radio resource control (RRC) signaling. The uplink TCI state may include a source reference signal which provides a reference for determining uplink spatial domain transmission filter for the uplink transmission (e.g., dynamic-grant/configured-grant based physical uplink shared channel (PUSCH), dedicated physical uplink control channel (PUCCH) resources) in a component carrier (CC) or across a set of configured CCs and/or bandwidth parts (BWPs). In some cases, a joint downlink and/or uplink TCI state is provided if the device is configured with joint downlink and/or uplink TCI by RRC signaling (e.g., configuration of joint TCI or separate downlink and/or uplink TCI is based on RRC signaling). The joint downlink and/or uplink TCI state refers to at least a common source reference signal used for determining both the downlink QCL information and the uplink spatial transmission filter. The source reference signal determined from the indicated joint, or common, TCI state provides QCL Type-D indication (e.g., for a device-dedicated physical downlink control channel (PDCCH) and/or physical downlink shared channel (PDSCH)) and is used to determine am uplink spatial transmission filter (e.g., for UE-dedicated PUSCH and/or PUCCH) for a CC or across a set of configured CCs and/or BWPs. In some examples, the uplink spatial transmission filter is derived from the reference signal of downlink QCL Type D in the joint TCI state. The spatial setting of the uplink transmission may be according to the spatial relation with a reference to the source reference signal configured with QCL type set to ‘QCL-typeD’ in the joint TCI state.

**[0073]** In some cases, a spatial relation information associated with a target transmission can indicate parameters for configuring a spatial setting between the target transmission and a reference signal (e.g., SSB, CSI-RS, and/or SRS). For example, the device may transmit the target transmission with the same spatial domain filter used for reception the reference signal (e.g., downlink reference signal including an SSB and/or CSI-RS). In some other examples, the device may transmit the target transmission with the same spatial domain transmission filter used for the transmission of the reference signal (e.g., uplink reference signal including an SRS). A device can receive a configuration of a plurality of spatial relation information configurations for a serving cell for transmissions on the serving cell.

**[0074]** In some cases, an uplink TCI state is provided if a device is configured with separate downlink and/or uplink TCI by RRC signaling. The uplink TCI state may include a source reference signal, which provides a reference for determining an uplink spatial domain transmission filter for the uplink transmission (e.g., dynamic-grant and/or configured-grant based PUSCH, dedicated PUCCH resources) in a CC or across a set of configured CCs and/or BWPs. In some cases, a joint downlink and/or uplink TCI state is provided if the device is configured with joint downlink and/or uplink TCI by RRC signaling (e.g., configuration of joint TCI or separate downlink and/or uplink TCI is based on RRC signaling). The joint downlink and/or uplink TCI state refers to at least a common source reference signal used for determining both the downlink QCL information and the uplink spatial transmission filter. The source reference signal determined from the indicated joint, or common, TCI state provides QCL Type-D indication (e.g., for device-dedicated PDCCH and/or PDSCH) and is used to determine uplink spatial transmission filter (e.g., for UE-dedicated PUSCH and/or PUCCH) for a CC or across a set of configured CCs and/or BWPs. In one example, the uplink spatial transmission filter is derived from the reference signal of downlink QCL Type D in the joint TCI state. The spatial setting of the uplink transmission may be according to the spatial relation with a reference to the source reference signal configured with QCL type set to ‘QCL-typeD’ in the joint TCI state.

**[0075]** In some examples, an NE 102 may configure a UE 104 to report information to the NE 102 in uplink signaling. For example, the NE 102 may indicate for the UE 104 to transmit an aperiodic CSI report. In variations, the CSI reporting is triggered by control signaling, such as a downlink control information (DCI) format 0_1 message, a DCI format 0_2 message (e.g., by

applying a higher layer parameter *reportTriggerSizeDCI-0-2* instead of *reportTriggerSize*), and/or a DCI format 0_3 message. In some cases, an NE 102 may control one or more time and frequency resources that can be used by the UE 104 to report CSI. Example CSI may include, but is not limited to, a CQI, a precoding matrix indicator (PMI), a CSI-RS resource indicator (CRI), a synchronization signal and/or physical broadcast channel (PBCH) block resource indicator (SSBRI), a layer indicator (LI), a rank indicator (RI), an L1-RSRP, an L1-signal to interference plus noise ratio (SINR), a capability index parameter (e.g., *CapabilityIndex*), and/or one or more time domain channel properties (TDCP). For CQI, PMI, CRI, SSBRI, LI, RI, L1-RSRP, L1-SINR, CapabilityIndex, and/or TDCP a UE 104 is configured by higher layers with one or more parameters and/or configurations (e.g., N≥1 *CSI-ReportConfig* reporting settings, X≥1 *LTM-CSI-ReportConfig* Reporting settings, M≥1 *CSI-ResourceConfig* resource settings, and/or Y≥1 *LTM-CSI-ResourceConfig* resource settings), and one or more lists of trigger states.

**[0076]** In variations, the lists of trigger states may be indicated by one or more higher layer parameters (e.g., *CSI-AperiodicTriggerStateList* and *CSI-SemiPersistentOnPUSCH-TriggerStateList*). A trigger state in a list (e.g., *CSI-AperiodicTriggerStateList*) includes a list of associated CSI report configuration parameters (e.g., *CSI-ReportConfigs* or *LTM-CSI-ReportConfigs*) indicating a resource set identifier (ID) for a channel and optionally for interference. The configuration parameters may include a L1 and/or L2 triggered mobility (LMT) CSI report configuration parameter. In some cases, a resource set for interference can be present for a report setting given by a CSI report configuration parameter (e.g., *CSI-ReportConfig*). A trigger state additionally, or alternatively, includes one or more ID parameters (e.g., *csi-ReportSubConfigID*) if an associated CSI report configuration parameter (e.g., *CSI-ReportConfig*) is configured with a list of sub-configurations. A trigger state in a list (e.g., *CSI-SemiPersistentOnPUSCH-TriggerStateList*) may include an associated CSI report configuration (e.g., *CSI-ReportConfig* or *LTM-CSI-ReportConfig*), and a trigger state may additionally, or alternatively, include one or more ID parameters (e.g., *csi-ReportSubConfigID*) if an associated CSI report configuration parameter (e.g., *CSI-ReportConfig*) is configured with a list of sub-configurations.

**[0077]** In some examples, a reporting setting (e.g., *CSI-ReportConfig*) is associated with a single downlink BWP, which may be indicated by a higher layer parameter (e.g., *BWP-Id*), given in an associated *CSI-ResourceConfig* for channel measurement and includes one or more parameters

for a CSI reporting band. The parameters for a CSI reporting may include, but are not limited to, a codebook configuration including a codebook subset restriction, a time domain behavior, a frequency granularity for CQI and/or PMI, measurement restriction configurations, and the CSI-related quantities to be reported by the UE 104, such as an LI, L1-RSRP, L1-SINR, CRI, SSBRI, *CapabilityIndex*, and TDCP. A reporting setting (e.g., *LTM-CSI-ReportConfig*) may be associated with a resource configuration (e.g., *LTM-CSI-ResourceConfig*) for a channel measurement and may include one or more parameters for time domain behavior (e.g., provided by *ltm-ReportConfigType*), the numerical quantity of cells and the numerical quantity of reference signals per candidate cell (e.g., provided by *noOfReportedCells* and *noOfReportedRS-PerCell*, respectively), including L1 measurement results associated with a current cell (e.g., *SpCell* if *spCellInclusion* is configured).

**[0078]** In some examples, time domain behavior of a *CSI-ReportConfig* is indicated by a higher layer parameter *reportConfigType* and can have a value set to at least one of 'aperiodic,' 'semi-persistent on PUCCH,' 'semi-persistent on PUSCH,' or 'periodic.' For periodic, semi-persistent on PUCCH, and/or semi-persistent on PUSCH CSI reporting, the configured periodicity and slot offset applies in the numerology of the uplink BWP in which the CSI report is configured to be transmitted on. A higher layer parameter (e.g., *reportQuantity*) indicates a CSI-related, L1-RSRP related, L1-SINR related, capability index related or TDCP related quantities to report. A parameter (e.g., *reportFreqConfiguration*) indicates a reporting granularity in the frequency domain, including the CSI reporting band and if PMI and/or CQI reporting is wideband or sub-band. A parameter (e.g., *timeRestrictionForChannelMeasurements*) in a CSI report configuration (e.g., *CSI-ReportConfig*) can be configured to enable time domain restriction for channel measurements and a parameter (e.g., *timeRestrictionForInterferenceMeasurements*) can be configured to enable time domain restriction for interference measurements. A CSI report configuration (e.g., *CSI-ReportConfig*) can also include a codebook configuration (e.g., *CodebookConfig*), which includes configuration parameters for type I, type II, enhanced type II CSI, further enhanced type II port selection, enhanced type II for coherent joint transmission (CJT), Further enhanced type II port selection for CJT, enhanced type II for predicted PMI, or further enhanced type II port selection for predicted PMI, including codebook subset restriction when applicable, and configurations of group-based reporting.

**[0079]** In some examples, a UE 104 may not be configured with a CSI report setting associated with a dormant downlink BWP if a value of a *reportConfigType* parameter is set to aperiodic. A CSI report configuration (e.g., *CSI-ReportConfig*) can include a list of sub-configurations, provided by a higher layer parameter (e.g., *csi-ReportSubConfigList*), where a sub-configuration is identified by a parameter (e.g., *csi-ReportSubConfigID*) and corresponds to a list of one or more CSI-RS resources or corresponds to a CSI-RS antenna port subset, and/or corresponds to a power offset for PDSCH relative to CSI-RS additional to a power control offset of the CSI-RS resources. A UE 104 may not be configured with a CSI report configuration (e.g., *CSI-ReportConfig*) that includes a mix of sub-configurations corresponding to a list of one or more CSI-RS resources and some other sub-configurations corresponding to CSI-RS antenna port subset. In some examples, the time domain behavior of an LTM CSI report configuration (e.g., *LTM-CSI-ReportConfig*) is indicated by a higher layer parameter (e.g., *ltm-ReportConfigType*) and can be set to a value of 'aperiodic,' 'semiPersistentOnPUCCH,' 'semiPersistentOnPUSCH,' or 'periodic.' For periodic, semiPersistentOnPUCCH, and/or semiPersistentOnPUSCH CSI reporting, the configured periodicity and slot offset applies in the numerology of the uplink BWP in which the CSI report is configured to be transmitted on.

**[0080]** A CSI resource setting (e.g., *CSI-ResourceConfig*) includes a configuration of a list of $S \geqslant 1$ CSI resource sets (e.g., given by higher layer parameter *csi-RS-ResourceSetList*), where the list includes references to either or both of non-zero power (NZP) CSI-RS resource sets and synchronization signal and/or PBCH block sets or the list includes references to CSI-interference measurement (IM) resource sets. A CSI resource setting is located in the downlink BWP identified by the higher layer parameter *BWP-id*, and CSI resource settings linked to a CSI report setting may have a same downlink BWP.

**[0081]** A time domain behavior of a CSI-RS resources within a CSI resource setting is indicated by a higher layer parameter (e.g., *resourceType*) and can be set to aperiodic, periodic, or semi-persistent. For periodic and semi-persistent CSI resource settings, when the UE 104 is configured with group based beam reporting (e.g*., groupBasedBeamReporting-r17* or *groupBasedBeamReporting-v18*), the numerical quantity of CSI resource sets configured is S=2, otherwise the numerical quantity of CSI-RS resource sets configured is S=1, except for periodic CSI resource settings, when the UE 104 is configured with TDCP reporting, for which the numerical

quantity of CSI-RS resource sets in the CSI resource setting for channel measurement is K_TRS∈ {1,2,3} and the CSI-RS resource sets are configured with a higher layer parameter (e.g., *trs-Info*). For periodic and semi-persistent CSI resource settings, the configured periodicity and slot offset is given in the numerology of its associated downlink BWP, as given by *BWP-id*. When a UE 104 is configured with multiple *CSI-ResourceConfigs* including a same NZP CSI-RS resource ID, a same time domain behavior may be configured for the *CSI-ResourceConfigs*. When a UE 104 is configured with multiple *CSI-ResourceConfigs* including a same CSI-IM resource ID, a same time-domain behavior may be configured for the *CSI-ResourceConfigs*. One or more CSI resource settings linked to a CSI report setting may have the same time domain behavior.

**[0082]** In some examples, an NE 102 may configure one or more CSI resource settings for channel and interference measurement via higher layer signaling. For example, the NE 102 may configure a CSI-IM resource for interference measurement, an NZP CSI-RS resource for interference measurement, and/or an NZP CSI-RS resource for channel measurement. In some examples, the UE 104 may determine that the NZP CSI-RS resources for channel measurement and the CSI-IM resources for interference measurement configured for one CSI reporting are resource-wise QCLed with respect to 'typeD.' When NZP CSI-RS resources are used for interference measurement, the UE 104 may determine that the NZP CSI-RS resource for channel measurement and the CSI-IM resource or NZP CSI-RS resources for interference measurement configured for one CSI reporting are QCLed with respect to 'typeD.'

**[0083]** In some cases, such as for TDCP measurement, a periodic CSI resource setting is configured, and the resource setting is for channel measurement on CSI-RS for tracking. For L1-SINR measurement, when a resource setting is configured, the resource setting (e.g., given by higher layer parameter r*esourcesForChannelMeasurement*) may be for channel and interference measurement on a NZP CSI-RS for L1-SINR computation. In some cases, a UE 104 may determine that a same 1 port NZP CSI-RS with density 3 resource elements (REs) and/or resource blocks (RBs) is used for both channel and interference measurements. When two resource settings are configured, the first resource setting (e.g., given by higher layer parameter *resourcesForChannelMeasurement*) may be for channel measurement on an SSB or NZP CSI-RS and the second resource setting (e.g., given by either higher layer parameter *csi-IM-ResourcesForInterference* or higher layer parameter *nzp-CSI-RS-ResourcesForInterference*) may be

for interference measurement performed on CSI-IM or on 1 port NZP CSI-RS with density 3 Res and/or RB, where an SSB or NZP CSI-RS resource for channel measurement is associated with one CSI-IM resource or one NZP CSI-RS resource for interference measurement by the ordering of the SSB or NZP CSI-RS resource for channel measurement and CSI-IM resource or NZP CSI-RS resource for interference measurement in the corresponding resource sets. The numerical quantity of SSBs or CSI-RS resources for channel measurement may be equal to the numerical quantity of CSI-IM resources or the numerical quantity of NZP CSI-RS resource for interference measurement.

**[0084]** In some examples, a UE 104 may apply an SSB, or 'typeD' reference configured with a *qcl-Type* set to 'typeD' to the NZP CSI-RS resource for channel measurement, as the reference signal for determining 'typeD' for a corresponding CSI-IM resource or the corresponding NZP CSI-RS resource for interference measurement configured for one CSI reporting. A UE 104 may determine that an NZP CSI-RS resource set for channel measurement and the NZP-CSI-RS resource set for interference measurement, if any, are configured with the higher layer parameter repetition. An LTM CSI resource setting (e.g., *LTM-CSI-ResourceConfig*) may include a configuration of a resource set (e.g., *LTM-CSI-SSB-ResourceSet*), which may include a list of $Z \geqslant 1$ synchrozniation signal and/or PBCH block indices (e.g., given by *ltm-CSI-SSB-ResourceList*) and a list of Z (e.g., *LTM-CandidateIds* given by *ltm-CandidateIDList*) referring to candidate cells associated with the synchronization signal and/or PBCH block indices. For each candidate cell, a UE 104 may determine a time domain behavior of a synchronization signal and/or PBCH block from one or more parameters (e.g., *ssb-Periodicity* and *ssb-PositionsInBurst*) and the frequency domain behavior of a synchronization signal and/or PBCH block by one or more higher layer parameters (e.g., *subCarrierSpacing*, *ssbFrequency*).

**[0085]** In some examples, a UE 104 may calculate CSI parameters based on one or more dependencies between CSI parameters. For example, LI may be calculated conditioned on the reported CQI, PMI, RI, and CRI. Additionally, or alternatively, CQI may be calculated conditioned on the reported PMI, RI, and CRI. Additionally, or alternatively, PMI may be calculated conditioned on the reported RI and CRI. Additionally, or alternatively, RI may be calculated conditioned on the reported CRI. The reporting configuration for CSI can be aperiodic (e.g., using PUSCH), periodic (e.g., using PUCCH), or semi-persistent (e.g., using PUCCH, and DCI activated PUSCH). The CSI-RS resources can be periodic, semi-persistent, or aperiodic. Periodic CSI-RS is

configured by higher layers. Semi-persistent CSI-RS is activated and deactivated. Aperiodic CSI-RS is configured and triggered and/or activated. When the UE 104 is configured with a higher layer parameter *NZP-CSI-RS-ResourceSet* and when the higher layer parameter repetition is set to 'off,' the UE 104 may determine a CRI from the supported set of CRI values and report the number in a CRI report. When the higher layer parameter repetition for a CSI-RS resource set for channel measurement is set to 'on,' CRI for the CSI-RS resource set for channel measurement is not reported. CRI reporting is not supported when the higher layer parameter *codebookType* may be set to a value (e.g., 'typeII,' 'typeII-PortSelection,' 'typeII-r16,' 'typeII-PortSelection-r16,' 'typeII-PortSelection-r17,' 'typeII-CJT-r18,' 'typeII-CJT-PortSelection-r18,' 'typeII-Doppler-r18' and/or 'typeII-Doppler-PortSelection-r18').

**[0086]** In some cases, such as for a semi-persistent or aperiodic CSI report on a PUSCH, slot offsets may be configured by one or more higher layer parameters. For example, if triggered and/or activated by DCI format 0_2 and the higher layer parameter *reportSlotOffsetListDCI-0-2* or *reportSlotOffsetListDCI-0-2-r17* is configured, then the slot offsets are configured by *reportSlotOffsetListDCI-0-2* or *reportSlotOffsetListDCI-0-2-r17*, and if triggered and/or activated by DCI format 0_1 or 0_3 and the higher layer parameter *reportSlotOffsetListDCI-0-1* or *reportSlotOffsetListDCI-0-1-r17* is configured, then the slot offsets are configured by *reportSlotOffsetListDCI-0-1* or *reportSlotOffsetListDCI-0-1-r17*, and otherwise, the slot offsets are configured by the higher layer parameter r*eportSlotOffsetList* or *reportSlotOffsetList-r17*.

**[0087]** In some examples, the offset is selected in the activating and/or triggering DCI. For CSI reporting, a UE 104 can be configured via higher layer signaling with a sub-band size, where a sub-band is defined as a set of contiguous PRBs and depends on a total numerical quantity of PRBs in a BWP. The r*eportFreqConfiguration* included in a CSI report configuration (e.g., *CSI-ReportConfig*) indicates a frequency granularity of the CSI report. A CSI reporting setting configuration defines a CSI reporting band as a subset of sub-bands of a BWP. The *reportFreqConfiguration* indicates a *csi-ReportingBand* as a contiguous or non-contiguous subset of sub-bands in the BWP for which CSI may be reported. A UE 104 may not be configured with *csi-ReportingBand*, which includes a sub-band where a CSI-RS resource linked to the CSI report setting has the frequency density of each CSI-RS port per PRB in the sub-band less than the configured density of the CSI-RS resource. If a CSI-IM resource is linked to the CSI report setting, a UE 104 may not be configured with *csi-*

*ReportingBand*, which includes a sub-band where not all PRBs in the sub-band have the CSI-IM REs present. A UE 104 can be configured via higher layer signaling with a wideband CQI or sub-band CQI reporting, as configured by the higher layer parameter *cqi-FormatIndicator*. In some examples, when wideband CQI reporting is configured, a wideband CQI is reported for a codeword for a CSI reporting band. When sub-band CQI reporting is configured, one CQI per codeword is reported for respective sub-bands in the CSI reporting band. A UE 104 can be configured via higher layer signaling with wideband PMI or sub-band PMI reporting as configured by the higher layer parameter *pmi-FormatIndicator*. When wideband PMI reporting is configured, a wideband PMI is reported for a CSI reporting band. When sub-band PMI reporting is configured, except with 2 antenna ports, a single wideband is reported for a CSI reporting band and one sub-band indication is reported for respective sub-bands in the CSI reporting band. When sub-band PMIs are configured with 2 antenna ports, a PMI is reported for respective sub-bands in the CSI reporting band.

**[0088]** In some examples, a UE 104 may not be configured with *pmi-FormatIndicator* if *codebookType* is set to 'typeII-r16,' 'typeII-PortSelection-r16,' 'typeII-PortSelection-r17,' 'typeII-CJT-r18,' 'typeII-CJT-PortSelection-r18,' 'typeII-Doppler-r18' or 'typeII-Doppler-PortSelection-r18.' A CSI reporting setting is said to have a wideband frequency granularity if *reportQuantity* is set to 'cri-RI-PMI-CQI,' or 'cri-RI-LI-PMI-CQI,' cqi-FormatIndicator is set to 'widebandCQI' and pmi-FormatIndicator is set to 'widebandPMI,' or *reportQuantity* is set to 'cri-RI-PMI-CQI,' codebookType is set to 'typeII-PortSelection-r17,' 'typeII-CJT-PortSelection-r18' or 'typeII-Doppler-PortSelection-r18' with M=1 and cqi-FormatIndicator is set to 'widebandCQI,' or *reportQuantity* is set to 'cri-RI-i1' or *reportQuantity* is set to 'cri-RI-CQI' or 'cri-RI-i1-CQI' and cqi-FormatIndicator is set to 'widebandCQI,' or *reportQuantity* is set to 'cri-RSRP' or 'ssb-Index-RSRP' or 'cri-SINR,' or 'ssb-Index-SINR' or 'cri-RSRP-Index' or 'ssb-Index-RSRP-Index' or 'cri-SINR-Index,' or 'ssb-Index-SINR-Index,' or *reportQuantity* is set to 'tdcp' otherwise, the CSI reporting setting has a sub-band frequency granularity.

**[0089]** If the UE 104 is configured with a CSI reporting setting for a BWP with fewer than 24 PRBs, the CSI reporting setting may have a wideband frequency granularity, and, if applicable, the higher layer parameter *codebookType* is set to 'typeI-SinglePanel.' If a UE 104 is configured with semi-persistent CSI reporting, the UE 104 may report CSI when both CSI-IM and NZP CSI-RS resources are configured as periodic or semi-persistent. If a UE 104 is configured with aperiodic

CSI reporting, the UE 104 may report CSI when both CSI-IM and NZP CSI-RS resources are configured as periodic, semi-persistent, or aperiodic. A UE 104 configured with DCI format 0_1, 0_2 or 0_3 may not be triggered with multiple CSI reports with a same *CSI-ReportConfigId*.

**[0090]** In some cases, for aperiodic CSI, a trigger state configured using the higher layer parameter *CSI-AperiodicTriggerState* may be associated with one or more CSI report configurations (e.g., *CSI-ReportConfig*), where the CSI report configuration not configured with group-based beam reporting (e.g., g*roupBasedBeamReporting-r17* or *groupBasedBeamReporting-v18*) is linked to periodic, or semi-persistent, or aperiodic resource settings. When one resource setting is configured, the resource setting (e.g., given by higher layer parameter *resourcesForChannelMeasurement*) may be for channel measurement for L1-RSRP or for channel and interference measurement for L1-SINR computation. When two resource settings are configured, the first one resource setting (e.g., given by higher layer parameter *resourcesForChannelMeasurement*) may be for channel measurement and the second one (e.g., given by either higher layer parameter *csi-IM-ResourcesForInterference* or higher layer parameter *nzp-CSI-RS-ResourcesForInterference*) may be for interference measurement performed on CSI-IM or on NZP CSI-RS. When three resource settings are configured, the first resource setting (e.g., higher layer parameter *resourcesForChannelMeasurement*) may be for channel measurement, the second one (e.g., given by higher layer parameter *csi-IM-ResourcesForInterference*) may be for CSI-IM based interference measurement, and the third one (e.g., given by higher layer parameter *nzp-CSI-RS-ResourcesForInterference*) may be for NZP CSI-RS based interference measurement.

**[0091]** For aperiodic CSI, and for periodic and semi-persistent CSI resource settings, a trigger state configured using the higher layer parameter *CSI-AperiodicTriggerState* may be associated with one or more CSI report configurations (e.g., *CSI-ReportConfig*), where the CSI report configuration configured with group-based beam reporting (e.g., *groupBasedBeamReporting-r17* or *groupBasedBeamReporting-v18*) is linked to periodic or semi-persistent settings. When one resource setting is configured, the resource setting is given by *resourcesForChannelMeasurement* for L1-RSRP measurement. In some examples, the numerical quantity of configured CSI resource sets in the resource setting is S=2. For aperiodic CSI, and for aperiodic CSI resource settings, a trigger state configured using the higher layer parameter *CSI-AperiodicTriggerState* may be associated with one or more CSI report configurations (e.g., *CSI-ReportConfig*), where the CSI

report configuration configured with group-based beam reporting may be associated with *resourcesForChannel* and *resourcesForChannel2*, which correspond to first and second resource sets, respectively, for L1-RSRP measurement.

**[0092]** In some examples, for semi-persistent or periodic CSI, a CSI report configuration (e.g., *CSI-ReportConfig*) is linked to periodic or semi-persistent resource settings. When one resource setting (e.g., given by higher layer parameter *resourcesForChannelMeasurement*) is configured, the resource setting is for channel measurement for L1-RSRP or for channel and interference measurement for L1-SINR computation. When two resource settings are configured, the first resource setting (e.g., given by higher layer parameter *resourcesForChannelMeasurement*) is for channel measurement and the second resource setting (e.g., given by higher layer parameter *csi-IM-ResourcesForInterference*) is used for interference measurement performed on CSI-IM. For L1-SINR computation, the second resource setting (e.g., given by higher layer parameter csi-IM-*ResourcesForInterference* or higher layer parameter *nzp-CSI-RS-ResourceForInterference*) is used for interference measurement performed on CSI-IM or on NZP CSI-RS.

**[0093]** For aperiodic CSI, a UE 104 configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'tdcp' may be configured with one CSI resource setting (e.g., given by higher layer parameter *resourcesForChannelMeasurement*). The CSI resource setting may be periodic, with K_TRS$\in$ {1,2,3} CSI-RS resource sets configured with higher layer parameter *trs-Info*. The support of K_TRS=2 or 3 is subject to a UE capability indication. For a periodic *CSI-ResourceConfig*, the UE 104 can determine that the CSI-RS resources in the K_TRS CSI-RS resource sets share a same QCL-TypeA/C and, if applicable, TypeD. The UE 104 may determine that the CSI-RS resources in the CSI-RS resource sets are configured with a same bandwidth and subcarrier locations. A UE 104 configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'tdcp' may not be configured with interference measurement on CSI-IM and/or NZP-CSI-RS.

**[0094]** In some examples, for a UE 104 configured with a CSI report configuration (e.g., *LTM-CSI-ReportConfig*), the aperiodic, semi-persistent, or periodic CSI are associated with one resource setting given by a parameter (e.g., *ltm-ResourcesForChannelMeasurement*) for L1-RSRP measurement. A UE 104 may not be configured with more than one CSI-RS resource in resource set

for channel measurement for a *CSI-ReportConfig* with the higher layer parameter *codebookType* set to 'typeII,' 'typeII-PortSelection,' 'typeII-r16,' 'typeII-PortSelection-r16,' or 'typeII-PortSelection-r17.' A UE 104 may not be configured with more than 64 NZP CSI-RS resources and/or synchronization signal and/or PBCH block resources in resource setting for channel measurement for a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'none,' 'cri-RI-CQI,' 'cri-RSRP,' 'ssb-Index-RSRP,' 'cri-SINR' or 'ssb-Index-SINR,' 'cri-RSRP- Index,' 'ssb-Index-RSRP- Index,' 'cri-SINR- Index' or 'ssb-Index-SINR- Index.' If interference measurement is performed on CSI-IM, a CSI-RS resource for channel measurement is resource-wise associated with a CSI-IM resource by the ordering of the CSI-RS resource and CSI-IM resource in the corresponding resource sets. The numerical quantity of CSI-RS resources for channel measurement is equal to the numerical quantity of CSI-IM resources.

**[0095]** A UE 104 configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RI-PMI-CQI' and *codebookType* set to 'typeII-CJT-r18' or 'typeII-CJT-PortSelection-r18' may be configured with $1 \leqslant K \leqslant 4$ CSI-RS resources in a resource set for channel measurement. If interference measurement is performed on CSI-IM, one resource is configured in the corresponding *csi-IM-ResourceSet*. If interference measurement is performed on NZP CSI-RS, one resource is configured in the corresponding *NZP-CSI-RS-ResourceSet* for interference measurement. A UE 104 configured with a *CSI-ReportConfig* with the higher layer parameter *N4* and *reportQuantity* set to 'cri-RI-PMI-CQI,' may be configured with $K \in \{4,8,12\}$ aperiodic CSI-RS resources or with a single periodic or semi-persistent CSI-RS resource in the resource set for channel measurement. For an aperiodic CSI-RS resource set for channel measurement, the *K* CSI-RS resources are triggered by a same triggering instance and the separation between two consecutive CSI-RS resources is $m \in \{1,2\}$ slots, which is configured by a higher layer parameter in the *NZP-CSI-RS-ResourceSet*. The *K* aperiodic CSI-RS resources are transmitted following the order of the CSI-RS resource IDs configured in the CSI-RS resource set. The UE 104 may determine that the antenna port with the same port index of the *K* aperiodic CSI-RS resources is the same. If interference measurement is performed on CSI-IM, one resource is configured in the corresponding *csi-IM-ResourceSet*. If interference measurement is performed on NZP CSI-RS, one resource is configured in the corresponding *NZP-CSI-RS-ResourceSet* for interference measurement.

**[0096]** An NZP CSI-RS resource set for channel measurement with $2 \leqslant K_s \leqslant 8$ resources can be configured with two resource groups, with $K_1 \geqslant 1$ resources in Group 1 and $K_2 \geqslant 1$ resources in Group 2, such that $K_1+K_2=K_s$, and with $N \in \{1,2\}$ resource pairs. A resource pair may include one resource from Group 1 and one resource from Group 2. The same resource can be associated with two resource pairs in frequency range 1 but not in frequency range 2. A subset of resources, where a subset includes one or more resources, of a NZP CSI-RS resource set for channel measurement corresponds to a sub-configuration included in a *CSI-ReportConfig* if respective sub-configurations include a list of one or more NZP CSI-RS resources, or the resources of a NZP CSI-RS resource set for channel measurement correspond to the respective sub-configurations included in a *CSI-ReportConfig* if the respective sub-configurations do not include a list of NZP CSI-RS resources.

**[0097]** Except for L1-SINR, *codebookType* set to 'typeII-CJT-r18,' 'typeII-CJT-PortSelection-r18,' 'typeII-Doppler-r18,' or 'typeII-Doppler-PortSelection-r18,' if interference measurement is performed on NZP CSI-RS, a UE 104 may not be configured with more than one NZP CSI-RS resource in the associated resource set within the resource setting for channel measurement. Except for L1-SINR, the UE 104 configured with the higher layer parameter *nzp-CSI-RS-ResourcesForInterference* may determine that no more than 18 NZP CSI-RS ports are configured in a NZP CSI-RS resource set. For CSI measurements other than L1-SINR, a UE 104 may determine respective NZP CSI-RS ports are configured for interference measurement corresponding to an interference transmission layer, interference transmission layers on NZP CSI-RS ports for interference measurement account for an associated energy per resource element (EPRE) ratios, and/or other interference signal on REs of NZP CSI-RS resource for channel measurement, NZP CSI-RS resource for interference measurement, or CSI-IM resource for interference measurement.

**[0098]** For L1-SINR measurement with dedicated interference measurement resources, a UE 104 may determine a total received power on dedicated NZP CSI-RS resource for interference measurement or dedicated CSI-IM resource for interference measurement corresponds to interference and noise. In some examples, for resource allocation in a frequency domain for SBFD operation, the NE 102 and/or the UE 104 may consider unaligned boundaries between RBGs and/or reporting sub-bands and SBFD sub-bands. For example, the NE 102 and/or the UE 104 may account for a RBG for PDSCH resource allocation type 0, a CSI reporting configuration, a CSI-RS

resource configuration, and/or a PRB group (PRG) of a PDSCH. For semi-static SBFD, for a CSI reporting sub-band which overlaps with SBFD sub-band boundaries, a CSI report is derived based on CSI-RS resources excluding CSI-RS resources outside downlink sub-bands for a UE 104. For semi-static SBFD, for a CSI-RS resource which overlaps with SBFD sub-band boundaries, CSI-RS resources within downlink sub-bands are valid for a UE 104. In some examples, frequency resource allocation for CSI-RS across downlink sub-bands for UEs 104 may include two contiguous CSI-RS resources that are linked, one CSI-RS resource, non-contiguous CSI-RS resource allocation, and/or one contiguous CSI-RS resource allocation with non-contiguous CSI-RS resource derived by excluding frequency resources outside downlink sub-bands.

**[0099]** For a CSI report associated with periodic or semi-persistent CSI-RS from a UE 104 aware of SBFD operation, if the periodicity is such that CSI-RS instances occur in both SBFD symbols and non-SBFD symbols in different slots (e.g., each CSI-RS resource within a slot has either all SBFD or all non-SBFD symbols), then the UE 104 may be configured with two *CSI-ReportConfigs*, where one may be associated with SBFD symbols and the other may be associated with non-SBFD symbols. A non-SBFD symbol and/or a non-SBFD time resource may be a time resource that is not allocated for communications using an SBFD communication scheme. One *CSI-ReportConfig* may be associated with a CSI-RS restricted to SBFD symbols and the second CSI-ReportConfig may be associated with a second CSI-RS restricted to non-SBFD symbols. Additionally, or alternatively, both *CSI-ReportConfigs* may be associated with a same CSI-RS. The CSI report with one *CSI-ReportConfig* may be derived based on CSI-RS instances in SBFD symbols. The CSI report associated with the second *CSI-ReportConfig* may be derived based on CSI-RS instances in non-SBFD symbols. Additionally, or alternatively, the UE 104 may be configured with one *CSI-ReportConfig* associated with both SBFD symbols and non-SBFD symbols. One *CSI-ReportConfig* may be associated with two CSI-RSs which are restricted to SBFD symbols and non-SBFD symbols, respectively. Separate CSI measurements are derived based on the first and second CSI-RSs respectively. One *CSI-ReportConfig* may be associated with one CSI-RS. The CSI report is derived based on CSI-RS, which can be in SBFD symbols or non-SBFD symbols in different time instances. In some examples, whether the CSI-RS resource can be used for SBFD and non-SBFD symbols may depend on an NE 102 using a same and/or different antenna configuration in both symbols.

**[0100]** According to implementations, one or more of the NEs 102 and the UEs 104 are operable to implement various aspects of the techniques described with reference to the present disclosure. For example, an NE 102 (e.g., a base station) may transmit signaling to UE 104 that indicates one or more sub-bands within a CSI-RS frequency band allocated for transmission of a CSI-RS. The NE 102 may transmit additional signaling to the UE 104 configuring a CSI report. For example, the additional signaling may indicate for the CSI report to include a measurement of a CSI-RS, an indication that the measurement is obtained by measuring an SBFD time resource or a non-SBFD time resource, an indication of a subset of frequency sub-bands, and/or an indication of an error status of the measurement. Additionally, or alternatively, the additional signaling may indicate for the CSI report to include one or more measured CSI values, an error status of one or more monitoring occasions that include a CSI-RS, an indication of one or more frequency resources for the measured CSI values, and/or a measurement technique for obtaining the CSI values. In some examples, the NE 102 and/or another device may transmit one or more CSI-RSs to the UE 104 using the indicated sub-bands within the CSI-RS frequency band. The UE 104 may selectively measure the CSI-RSs according to a criteria, which is described in further detail with respect to Figure 2 and may transmit a CSI report to the NE 102 according to the additional signaling.

**[0101]** **Figure 2** illustrates an example of wireless communications system 200 in accordance with aspects of the present disclosure. In some examples, the wireless communications system 200 implements aspects of the wireless communications system 100. For example, the wireless communications system 200 includes a UE 104 and an NE 102, which may be examples of a UE 104 and an NE 102 as described with reference to Figure 1. In some examples, an NE 102 may be in wireless communications with one or more other devices (e.g., the UE 104) in the wireless communications system 200. For example, the NE 102 may transmit and/or receive signaling from one or more UEs, including the UE 104. The NE 102 may transmit signaling to the UE 104 via a downlink communications link 202. Additionally, or alternatively, the UE 104 may transmit signaling to the NE 102 via an uplink communications link 204. The signaling between the NE 102 and the UE 104 may include control signaling and/or data transmissions.

**[0102]** In some cases, a UE 104 may be connected to an NE 102 (e.g., a base station). For example, the base station may be a RAN node operating according to a 4G, 5G, and/or 6G RAN

(e.g., a TRP, a consumer premise equipment (CPE), an integrated access and backhaul (IAB) node, a relay, or the like).

**[0103]** The NE 102 and/or the UE 104 may implement one or more different communications schemes, including, but not limited to, a TDD communication scheme and/or an SBFD communication scheme. In the wireless communications system 100, TDD refers to a communication scheme in which radio resources are split between a downlink communication direction and an uplink communication direction in a time domain. In a TDD communication scheme, at any point in time for a given frequency, either an NE 102 (e.g., a base station) transmits signals to one or more subscriber devices, or vice versa, which is described in further detail with respect to Figure 3. In conventional cellular systems that employ TDD, patterns of TDD are synchronized and may be identical, so as to avoid cross-link interference (CLI). In some examples, one or more devices in the wireless communications system 100 may additionally, or alternatively, implement a duplexing communication scheme. For example, the devices may implement an SBFD communication scheme and/or SBFD operation, where one or more UEs 104 may be configured to transmit uplink signals in a sub-band using symbols allocated for downlink signaling, or vice versa, which is described in further detail with respect to Figure 4. The UEs 104 may not be expected to have full-duplex capability on the sub-band, but an NE 102 may implement duplexing enhancements for communications on the sub-band. In some examples, such as for SBFD operation at an NE 102 within a TDD carrier, a UE 104 may implement transmission, reception, and measurement behavior and procedures in SBFD symbols and/or non-SBFD symbols. Additionally, or alternatively, the NE 102 may allocate communication resources in a frequency domain in SBFD symbols, including resource allocation in the frequency domain for PDSCH and/or CSI-RS across two downlink sub-bands in SBFD symbols, resource allocation for unaligned boundaries between SBFD sub-bands and a resource block group (RBG), resource allocation for a CSI reporting sub-band, resource allocation for one or more CSI-RS resources, and/or resource allocation for a PRG.

**[0104]** In some examples, a UE 104 and/or an NE 102 may determine one or more CSI-RS frequency resources in the presence of uplink sub-bands for semi-static and dynamic SBFD operation. For example, the UE 104 may be configured with an SBFD resource configuration. With SBFD, a sub-band in the bandwidth of a wireless link is configured to perform a communication in a direction that is different from the direction of communications in the rest of the bandwidth. For

example, an uplink sub-band on a downlink symbol refers to a sub-band within the downlink bandwidth that may be used for uplink communications.

**[0105]** In some examples, an NE 102, another base station, and/or a RAN node configures a UE 104 with a CSI-RS for channel state measurement, interference measurement, beam management, or the like. For example, the NE 102 may transmit the CSI-RS configuration signaling 206 to the UE 104 via the downlink communications link 202. In some examples, the CSI-RS configuration signaling 206 may include an explicit indication of one or more frequency resources for measuring a CSI-RS 208 in a CSI-RS frequency band. For example, the UE 104 may determine the frequency resources (e.g., sub-bands, PRBs, RBGs) to include or exclude for performing a measurement on a CSI-RS 208 based on signaling from the RRC and/or L1 or L2. This approach may be referred to as explicit signaling. The CSI-RS configuration signaling 206 may include a parameter that indicates a list of sub-bands to include and/or exclude. A sub-band may include a subset of a frequency band used for communications. A sub-band may be configured or indicated as one or more PRBs in an air interface based on OFDM and/or orthogonal frequency division multiple access (OFDMA). An entry (e.g., parameter) in the list may have a corresponding index or ID. The index can then be used in other communications, such as other configurations and/or L1 or L2 signaling. If the UE 104 operates with dynamic SBFD, L1, and/or L2 signaling may be used to indicate sub-band indices to include and/or exclude for the UE 104 to perform a measurement on a CSI-RS 208. In response, at 210, the UE 104 may perform one or more measurements on sub-bands within a CSI-RS frequency band. For example, the UE 104 may perform one or more measurements on the CSI-RS by including and/or excluding the indicated sub-bands. The UE 104 may then report the result of the measurement as configured by a CSI reporting or beam reporting configuration. For example, the NE 102 may transmit CSI report configuration signaling 212. The CSI report configuration signaling 212 may indicate one or more parameters for the UE 104 to include in a CSI report 214.

**[0106]** In some examples, a sub-band may be configured or indicated as one or more PRBs or RBGs. A sub-band may be configured by the RRC and/or indicated by L1 and/or L2 signaling. For example, a sub-band may be configured by two parameters such as {*Start-RB*, *Number-of-RBs*}, {*Start-RB*, *End-RB*}, or the like. Additionally, or alternatively, PRBs in the communication bandwidth (e.g., frequency band, carrier, CC, BWP) may be divided into groups of N consecutive RBs, where N is an integer preconfigured, defined, or indicated by the network. Example values for

N include, but are not limited to 1, 2, 4, etc. If the bandwidth is $N_{\mathrm{RB}}$ PRBs, then this method divides the bandwidth into M groups of N consecutive PRBs, where $M = \lceil N_{\mathrm{RB}}/N \rceil$. Then, if a group of N consecutive RBs is referred to as an RBG, a sub-band may be indicated by {*Start-RBG*, *Number-of-RBGs*}, {*Start-RBG*, *End-RBG*} or by a bitmap of length M in which each bit may indicate whether an associated RBG is included (e.g., if bit='1') or not included (e.g., if bit='0'). Note that if the number PRBs $N_{\mathrm{RB}}$ is not an integer multiple of N, then the first RBG and/or the last RBG may include a smaller numerical quantity of PRBs than N. Whether this is applicable to the first RBG or the last RBG may be preconfigured, defined, or indicated by the network.

**[0107]** In some examples, the CSI-RS configuration signaling 206 may include an information element and/or other configuration information that indicates one or more sub-bands for measuring the CSI-RS, which is described in further detail with respect to Figure 5 through Figure 11. Additionally, or alternatively, the CSI-RS configuration signaling 206 includes an implicit indication of the frequency resources for measuring the CSI-RS. For example, the UE 104 may determine the CSI-RS frequency resources for a CSI measurement based on information not indicated by a dedicated configuration or signaling. The UE 104 may determine the CSI-RS frequency resources in accordance with a preconfigured or defined configuration, a network configuration, UE implementation, UE capability features, or the like.

**[0108]** In some examples, the UE 104 may determine CSI-RS sub-bands based on one or more SBFD sub-bands. An SBFD sub-band may refer to a set of PRBs on which the direction of communication is different from the direction of communication outside the sub-band. For example, an uplink sub-band may refer to uplink PRBs on a downlink symbol, which is a symbol configured as downlink or configured as flexible and indicated and/or determined to be downlink. Similarly, a downlink sub-band may refer to downlink PRBs on an uplink symbol, which is a symbol configured as uplink or configured as flexible and indicated and/or determined to be downlink. In some cases, the NE 102 configures the UE 104 with a semi-static uplink sub-band. The NE 102 configures the UE 104 with a CSI-RS, where the frequency resources indicated by the CSI-RS configuration may overlap with the uplink sub-band. In response, the UE 104 may exclude the uplink sub-band frequency resources (e.g., PRBs, RBGs) for a measurement on the CSI-RS.

**[0109]** In some other cases, the UE 104 may determine whether the CSI-RS is on an SBFD symbol or a non-SBFD symbol. An SBFD symbol may refer to downlink or flexible symbol on

which the UE 104 may transmit an uplink signal within an uplink sub-band or an uplink or flexible symbol on which the UE 104 may receive a downlink signal within a downlink sub-band. If the UE 104 determines that the CSI-RS occurs on an SBFD symbol, then the UE 104 may exclude an uplink sub-band and/or include a downlink sub-band on the symbol for the measurement. Additionally, or alternatively, if the UE 104 determines that the CSI-RS does not occur on an SBFD symbol, then the UE 104 may determine the CSI-RS frequency resources based on other configurations or signaling irrespective of the SBFD sub-band configurations. In variations, the CSI-RS measurement and CSI reporting is not limited to wideband or narrowband CSI-RS and may also apply to the case that the CSI-RS is configured for one or more defined sub-bands, where the sub-bands are not identical to the SBFD sub-bands on the specific symbol.

**[0110]** In some cases, if the CSI-RS occupies multiple symbols from which at least one symbol is determined an SBFD symbol and at least one symbol is determined a non-SBFD symbol, then the UE 104 may treat the CSI-RS as if the CSI-RS is on an SBFD symbol (e.g., exclude an uplink sub-band and/or include a downlink sub-band in the CSI-RS frequency resources on the multiple symbols), may treat the CSI-RS as if the CSI-RS is on an SBFD symbol provided that this behavior does not conflict with another transmission and/or reception of a signal or channel by the UE 104, may treat the CSI-RS as if the CSI-RS is on a non-SBFD symbol (e.g., do not take SBFD sub-bands into consideration for determining the CSI-RS frequency resources on the multiple symbols), may treat the CSI-RS as if the CSI-RS is on a non-SBFD symbol provided that this behavior does not conflict with another transmission and/or reception of a signal or channel by the UE 104. In some examples, the UE 104 may determine that the measurement on the CSI-RS is an error case and/or that the status of the CSI-RS measurement has an error status.

**[0111]** In some other examples, the UE 104 may determine frequency resources based on a guard-band consideration. The UE 104 may not perform a measurement on a resource (e.g., PRB, RBG, RE) that is not separated from an uplink sub-band by at least a minimum guard-band (in units of kilohertz (kHz), PRBs, RBGs, etc.). If the UE 104 determines to perform a measurement on a CSI-RS with frequency resources that are not separated from an uplink sub-band by a minimum guard-band on a symbol, then the UE 104 may prioritize the uplink sub-band (e.g., neglect the CSI-RS frequency resources (e.g., PRBs, RBGs, REs) that are not separated from the uplink sub-band by the minimum guard-band), prioritize communications on the uplink sub-band (e.g., neglect the CSI-

RS frequency resources that are not separated from an uplink transmission (e.g., PUSCH, PUCCH, SRS) on the uplink sub-band by the minimum guard-band), prioritize the measurement (e.g., perform the measurement on the CSI-RS frequency resources, which may affect any communications on the uplink sub-band), and/or determine that the measurement on the CSI-RS is an error case. In variations, a minimum guard-band may be preconfigured, defined, configured by the network, indicated by an L1 and/or L2 signaling, determined according to an implementation or OAM setting, or any combination thereof. Any such methods for determining the CSI-RS frequency resources may be employed in combination with other methods, such as explicit signaling. In some cases, determining frequency resources of the CSI-RS according to explicit signaling (e.g., RRC, L1 and/or L2) and/or implicit determinations are collectively referred to as sub-band inclusion and/or exclusion, or similar terms.

**[0112]** In some examples, an NE 102 may signal one or more configurations to a UE 104 via the downlink communications link 202 (e.g., signaling configuring a UE 104). The signal and/or signaling may include RRC signaling, L1 and/or L2 messages, L1 and/or L2 indications, or L1 and/or L2 signaling, which may be used interchangeably and refer to signaling by lower layers, namely layer 1 and layer 2. An L1 control signaling may include one or more DCI messages signaled on a control channel, such as a PDCCH. An L2 control signaling may include a medium access control-control element (MAC-CE) message. Therefore, an L1 and/or L2 signaling may refer to a control signaling by lower layers and may include one or more DCI messages, one or more MAC-CE messages, and so on. In some examples, signaling by higher layers, such as the RRC, may be more reliable, but may occur according to a larger timescale. Conversely, signaling by lower layers such as L1 and/or L2 are associated with smaller timescales and lower reliability. Thus, for dynamic indications, L1 and/or L2 signaling may be more practical than, or may be used in addition to, semi-static configurations by the RRC.

**[0113]** For dynamic SBFD, an NE 102 may use both a semi-static SBFD configuration with lower layer signaling that dynamically indicates which sub-bands are to be used by the UE 104 for uplink or downlink communications. In some examples, SBFD configurations and signaling provide for uplink sub-bands on symbols that are configured or indicated as downlink symbols and/or downlink sub-bands on symbols that are configured or indicated as uplink symbols. In some cases, an RRC configuration indicates the sub-bands to include and/or exclude when performing a

measurement on the CSI-RS. For example, the CSI-RS configuration signaling 206 may be RRC signaling and may indicate the sub-bands to include and/or exclude when performing a measurement on the CSI-RS. In response, the UE 104 performs the measurement on the indicated CSI-RS frequency resources in a semi-static manner.

**[0114]** Additionally, or alternatively, the CSI-RS configuration signaling 206 may be any other type of control signaling, including, but not limited to, a DCI message and/or a MAC-CE. For example, an L1 and/or L2 signaling such as a DCI message or a MAC-CE message indicates sub-bands to include and/or exclude when performing a measurement on the CSI-RS. In response, the UE 104 may perform a CSI measurement on CSI-RS frequency resources as indicated by the L1 and/or L2 message. In some cases, the UE 104 may determine frequency resources by determining that an indication including and/or excluding a sub-band overrides an associated indication from an RRC configuration and/or an earlier L1 and/or L2 indication. In some other cases, the UE 104 may determine frequency resources by determining that an indication including a sub-band overrides an associated indication from an RRC configuration and/or a prior L1 and/or L2 indication. In yet other cases, the UE 104 may determine frequency resources by assuming that an indication excluding a sub-band overrides an associated indication from an RRC configuration and/or a prior L1 and/or L2 indication.

**[0115]** In some examples, the UE 104 may apply the sub-band inclusions and/or exclusions immediately (e.g., for the next CSI measurement on the associated CSI-RS). Additionally, or alternatively, the UE 104 may apply a timing for applying the sub-band inclusions and/or exclusions. For example, the UE 104 may perform and/or complete a CSI measurement and reporting based on an earlier configuration or L1 and/or L2 indication before applying the indicated sub-band inclusions and/or exclusions. For example, if a current or ongoing CSI measurement is to be performed during multiple measurement occasions, then the UE 104 may complete the CSI measurement before starting to apply the newly indicated sub-band inclusions and/or exclusions for the next measurement.

**[0116]** In some other examples, the UE 104 may apply a timing for a configured or defined duration or a numerical quantity of CSI measurements before switching back to sub-band inclusions and/or exclusions according to an earlier configuration or L1 and/or L2 indication. For example, the UE 104 may receive a dynamic L1 and/or L2 indication that is to override an associated semi-static

configuration fully or partially. The UE 104 may determine that the L1 and/or L2 indication is for the duration or the numerical quantity of CSI measurements (e.g., aperiodic indication) and not indefinite (e.g., semi-persistent indication). In some other examples, the UE 104 may receive an L1 indication that is to override an associated semi-static configuration and/or an earlier L2 indication. The UE 104 may determine that the L1 indication is for the duration or the numerical quantity of CSI measurements (e.g., aperiodic) while the semi-static configuration and/or the L2 indication is to be applied afterwards (e.g., semi-persistent).

**[0117]** In variations, one or more parameters may impact the timing, such as a duration to apply the inclusions and/or exclusions, a numerical quantity of CSI measurements, a numerical quantity of CSI monitoring occasions or CSI-RS resources, a start time to apply the inclusions and/or exclusions, an end time to apply the inclusions and/or exclusions, and so on, may be preconfigured or defined, configured by the network, indicated by an L1 and/or L2 signaling, determined according to an implementation or OAM setting, or any combination thereof. In some examples, the UE 104 may determine sub-band inclusions and/or exclusions by applying one or more rules in addition to, or as an alternative to, configurations and/or L1 and/or L2 indications. For example, the UE 104 may consider a minimum bandwidth (e.g., numerical quantity of total PRBs or REs) on which to perform a CSI measurement, because a measurement on a small numerical quantity of PRBs or REs may be inaccurate. However, since the UE 104 may consider multiple sub-band indications, for example from the RRC or lower layers, the indications may collectively result in a lower numerical quantity of PRBs or REs than the minimum. In some cases, the UE 104 may neglect, ignore, or drop one or more of the indications. For example, the UE 104 may neglect or ignore the latest L1 and/or L2 indication. In some other examples, the UE 104 may neglect or drop the earliest associated L1 and/or L2 indication that is still valid. In yet other examples, the UE 104 may neglect or drop one or more L1 and/or L2 indications and consider an associated semi-static configuration, or vice versa. In yet other examples, the UE 104 may neglect or drop one or more L1 indications and consider an associated semi-static configuration and/or L2 indications, or vice versa.

**[0118]** In various implementations, the UE 104 may prioritize semi-static configurations over L1 and/or L2 indications, or vice versa and/or may prioritize L2 indications over L1 indications, or vice versa. In some examples, prioritizing a first indication over a second indication may include neglecting or dropping the first indication if considering the first indication with the second

indication may collectively violate the minimum bandwidth for a measurement. The first indication may be neglected for one or more CSI measurements, or as long as the first indication results in the violation, or the first indication may be dropped from that point onwards. In some cases, the minimum bandwidth may be preconfigured or defined, configured by the network, indicated by an L1 and/or L2 signaling, determined according to an implementation or OAM setting, or any combination thereof.

**[0119]** In some examples, the UE 104 may be constrained to perform a measurement on a sub-band due to constraints from other configurations, indications, scheduling, communications, and so on. For example, if a UE 104 is to perform a measurement on PRBs or REs that are not separated from an uplink sub-band by a minimum guard-band, then the UE 104 may not be able to perform the measurement on the PRBs or REs. The constraint may be due to implementation or configuration. The UE 104 may apply a rule for neglecting or dropping one or more indications (e.g., by RRC and/or L1 and/or L2). The rules may be similar to the rules proposed for performing measurements on a minimum numerical quantity of PRBs or REs. In variations, the minimum guard-band may be preconfigured or defined, configured by the network, indicated by an L1 and/or L2 signaling, determined according to an implementation or OAM setting, or any combination thereof. If the UE 104 is to determine CSI-RS frequency resources based on conflicting explicit signaling and implicit determination, the UE 104 may prioritize explicit signaling per resource (e.g., include or exclude a CSI-RS resource in a measurement as indicated by the explicit signaling when conflicting with an implicit determination, but follow the implicit determination for resources that do not cause a conflict), prioritize implicit determination per resource (e.g., include or exclude a CSI-RS resource in a measurement as determined implicitly, but follow the explicit signaling for resources that do not cause a conflict), neglect or drop implicit determination (e.g., include or exclude CSI-RS resources in a measurement as indicated by the explicit signaling, and drop or neglect the implicit determination for resources that may or may not cause a conflict), neglect or drop explicit signaling (e.g., include or exclude CSI-RS resources in a measurement as determined implicitly, and drop or neglect the explicit signaling for resources that may or may not cause a conflict), and/or determine that the measurement on the CSI-RS 208 is an error case. Examples of explicit signaling are indications by RRC or L1 and/or L2 signaling. Examples of implicit determination are determining CSI-RS sub-bands based on SBFD sub-bands, applying a minimum

bandwidth, applying a minimum guard-band. The UE 104 may follow rules for determining priorities among a set of methods for determining CSI-RS frequency resources for a measurement, where each of the methods may include an explicit signaling, an implicit determination, or both. The rules may be preconfigured or defined, configured by the network, indicated by an L1 and/or L2 signaling, determined according to an implementation or OAM setting, or any combination thereof.

**[0120]** In some examples, a measurement may include an error case and/or have an error status. An error case may occur due to a variety of causes, including, but not limited to, the UE 104 receiving conflicting indications from one or more serving NEs, the UE 104 missing a control signaling from an NE 102 (e.g., due to an error receiving a DCI message), and/or the UE 104 detecting a conflict between an indication from a serving NE 102 and a capability of the UE 104 (e.g., a minimum guard-band). An error case may be accepted as a normal or common behavior of the UE 104 to reduce the system complexity. The UE 104 may determine to perform an action and/or no action when determining that a measurement on a CSI-RS 208 is an error case. For example, the UE 104 may neglect the measurement and not a send the associated CSI report 214, may neglect the measurement and send the associated CSI report 214 including an indication of the error case (e.g., a parameter with a NULL value, a CQI=0 value, an out-of-bound value, an indication of the type of the error case), may perform the measurement on a best-effort basis (e.g., include as many frequency resources for the CSI-RS 208 as possible based on the explicit signaling and/or implicit indication while excluding conflicting frequency resources; and then send the associated CSI report 214 including the measurement result), and/or may perform the measurement on a best-effort basis and send the associated CSI report 214 including the measurement result and an indication of the error case.

**[0121]** In some examples, a CSI report 214 may be enhanced to include information of CSI-RS frequency resources on which the UE 104 has performed a measurement to obtain CSI values. This method may be useful for scenarios in which the NE 102 may have ambiguity about the frequency resources of the CSI-RS measured by the UE 104 for producing CSI reports 214. Furthermore, a CSI report 214 with this format is self-contained, in that the CSI report 214 indicates the frequency resources to which the CSI values are associated. Thus, this enhanced CSI report format may reduce the NE 102 complexity for link adaptation and scheduling in the case that the frequency resources

monitored by the UE 104 change dynamically, which may be particularly useful when dynamic SBFD is employed.

**[0122]** In some examples, the UE 104 may send a CSI report 214 including one or more CSI values (e.g., measured at 210) and an indication of whether the CSI values are obtained by a measurement on an SBFD symbol or a non-SBFD symbol. The indication may be a bit for each of one or more CSI values. The CSI report 214 may include multiple such indications, each associated with one or more CSI values. In some other examples, the UE 104 may send a CSI report 214 including one or more CSI values and an indication of the sub-bands or frequency resources included and/or excluded for the measurement to obtain to the CSI values. The indication may include an ID and/or index indicated by a configuration that indicates sub-bands or frequency resources (e.g., an ID and/or index associated with a sub-band indicated by the parameter freqBand, freqBand2, freqBandSet, freqBandSets, and the like), an ID and/or index indicated by an L1 and/or L2 signaling that indicates sub-bands or frequency resources, a value of N (e.g., a numerical quantity of PRBs in an RBG and/or sub-band), a value of M (e.g., a numerical quantity of RBGs and/or sub-bands to include and/or exclude for a measurement), a value between 1 and K (e.g., a numerical quantity of sub-band inclusion and/or exclusion combinations), or equivalently a value between 0 and K-1, indicating which of the K sub-band inclusion and/or exclusion combinations were applied for the measurement to obtain the CSI values, and/or a bitmap indicating a sub-band inclusion and/or exclusion combination that was applied for the measurement to obtain the CSI values.

**[0123]** In some other examples, the UE 104 may send a CSI report 214 including one or more CSI values and an indication of an error case occurred when performing the measurement to obtain the CSI values. Examples of the error case include conflicting methods for determining CSI-RS frequency resources for the measurement. In some realizations, one or more of the CSI values may indicate the error case (e.g., a NULL value, a CQI=0 value, an out-of-bound value). The UE 104 behavior according to any of the examples and realizations may be preconfigured or defined, configured by the network, indicated by an L1 and/or L2 signaling, determined according to an implementation or OAM setting, or any combination thereof.

**[0124]** A CSI value may be obtained by combining results of multiple measurements, each measurement performed in a measurement occasion. The multiple measurement occasions may be

associated with a same reference signal, such as CSI-RS 208. For example, for obtaining a wideband CSI value, the UE 104 may perform multiple measurements on CSI-RS 208 with identical wideband frequency resources on multiple symbols. Similarly, for obtaining a narrowband CSI value, the UE 104 may perform multiple measurements on CSI-RS 208 with identical narrowband frequency resources, as indicated by the CSI-RS resource configuration, on multiple symbols. In variations, the UE 104 may determine different combinations of sub-bands or frequency resources in association with a same CSI-RS 208. If a CSI value is obtained based on one measurement or based on multiple measurements on identical and/or consistent frequency resources, the CSI value may be reported according to an enhanced CSI report format that includes an indication of the sub-band configuration associated with the CSI value. However, if a CSI value is to be obtained based on multiple measurements with unidentical and/or inconsistent frequency resources, the UE 104 may combine the results of the measurements.

**[0125]** In some examples, if the UE 104 obtains multiple CSI values based on unidentical and/or inconsistent frequency resources, the UE 104 may report the CSI values separately, such that CSI values with identical and/or consistent frequency resources are combined. In some other examples, the UE 104 may neglect one or more of the measurements that are to be performed on unidentical and/or inconsistent resources. The UE 104 may neglect the first measurement, the last measurement, the measurements that are in minority among all, measurements that are associated with the lowest total bandwidth, measurements that are associated with the highest total bandwidth, or the like. In some other examples, the UE 104 may combine results of the measurements on a union of the frequency resources (e.g., on the PRBs, RBGs, or sub-bands that are common among all or some of the frequency resources determined for the multiple monitoring occasions). The union may be referred to as the bandwidth overlap among the monitoring occasions. In some other examples, the UE 104 may combine results of the measurements based on a best-effort basis or in accordance with an implementation.

**[0126]** In some cases, in addition to, or as an alternative to, the one or more CSI values, the CSI report 214 may include an indication of an error case associated with unidentical and/or inconsistent frequency resources for multiple monitoring occasions, an indication of the frequency resources (e.g., sub-band and/or RBG inclusion and/or exclusion combinations) associated with one or more of the CSI values in the report, and/or an indication of the method used to resolve the inconsistency

of frequency resources for multiple monitoring occasions. The UE 104 behavior according to any of the examples and realizations may be preconfigured or defined, configured by the network, indicated by an L1 and/or L2 signaling, determined according to an implementation or OAM setting, or any combination thereof. In some examples, to realize an SBFD scheme, the NE 102 may employ analog and/or digital technologies that enables full-duplex operation on SBFD sub-bands. As a result, the antenna panels and configurations used for communications on SBFD symbols may be different from those used for communications on non-SBFD symbols, causing CSI values (e.g., including beam index values) that are significantly different between the two types of symbols, which is described in further detail with respect to Figures 12 and 13.

**[0127]** In some examples, the NE 102 may indicate to the UE 104 to measure and report CSI based on various configurations of frequency resources, but without using up the quota of CSI-RS resource configurations. This increases the complexity of the CSI measurement and reporting at the UE 104. Since different UEs 104 may have different capabilities to handle the complexity, new UE 104 capability features may be introduced to use in the UE 104 capability feature signaling to the network. The UE 104 may not expect to perform beyond what it indicates to the network through the signaling. For example, the UE 104 may indicate one or more capabilities in capability signaling 216. The UE 104 may include the capability signaling 216 in an existing control message or in a new control message (e.g., RRC signaling, a MAC-CE, and/or a DCI message). In some examples, the capability signaling 216 may include one or more parameters, such as a maximum numerical quantity of sub-bands configured by RRC and/or indicated by L1 and/or L2 signaling, a maximum numerical quantity of sub-band combinations activated and/or indicated at a time, a maximum numerical quantity of sub-band combinations activated and/or indicated during a certain period of T slots and/or symbols, a maximum numerical quantity of sub-band combination changes during a certain period of T slots and/or symbols, a minimum bandwidth (e.g., in units of kHz, PRBs, RBGs) for a valid measurement per contiguous sub-band or for a sum of noncontiguous sub-bands, a maximum numerical quantity of sub-bands per measurement a maximum numerical quantity of sub-band indications to include in a CSI report 214, a maximum numerical quantity of sub-band combinations for a CSI value based on multiple monitoring occasions, and/or a maximum numerical quantity of antenna panels or configurations (e.g., maximum numerical quantity of values

for *AntennaConfig*). In some cases, a minimum or maximum value for each of the UE capability features may be preconfigured or defined.

**[0128]** **Figure 3** illustrates an example of a resource diagram 300 in accordance with aspects of the present disclosure. In some examples, the resource diagram 300 implements aspects of the wireless communications system 100 and/or the wireless communications system 200. For example, the resource diagram 300 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The resource diagram 300 may illustrate an example of resource allocation for a TDD communication scheme.

**[0129]** In some examples, an NE may transmit signaling that schedules one or more time-frequency resources for a transmission to or from a UE. For example, the NE may schedule a control signaling transmission and/or a data transmission to or from the UE. The time-frequency resources may include one or more resources in the time domain, such as a slot. A slot may be a communication resource unit in the time domain, and may be further divided into one or more smaller units, referred to as symbols. In variations, the time resource 302 may be an example of a slot and/or a symbol. In some cases, respective time resources 302 may be allocated for uplink signaling and may be referred to as an uplink resource. In some other cases, the respective time resources 302 may be allocated for downlink signaling and may be referred to as a downlink resources.

**[0130]** In some examples, the NE may indicate a periodicity 304 over which a pattern of uplink resources and downlink resources are repeated. For example, the periodicity 304 may be any numerical quantity of slots and/or symbols over which a pattern of uplink resources and downlink resources is repeated. Although Figure 3 illustrates a periodicity 304 of 6 time resources 302, the periodicity 304 may be any numerical quantity of time resources 302. Additionally, or alternatively, the pattern may include any numerical quantity of uplink resources and/or downlink resources. During the uplink resources, a UE may transmit signaling to an NE, while during the downlink resources, a UE may receive signaling from an NE. A time resource 302 may be allocated to either uplink resources or downlink resources, but not both, for a TDD communication scheme.

**[0131]** **Figure 4** illustrates an example of a resource diagram 400 in accordance with aspects of the present disclosure. In some examples, the resource diagram 400 implements aspects of the

wireless communications system 100, the wireless communications system 200, and/or the resource diagram 300. For example, the resource diagram 400 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The resource diagram 400 may illustrate an example of resource allocation for an SBFD communication scheme.

**[0132]** In some examples, an NE may transmit signaling that schedules one or more time-frequency resources for a transmission to or from a UE. For example, the NE may schedule a control signaling transmission and/or a data transmission to or from the UE. The time-frequency resources may include one or more resources in the time domain, such as a slot and/or one or more symbols. In variations, the time resource 402 may be an example of a slot and/or a symbol. In some cases, respective time resources 402 may be allocated for uplink signaling and may be referred to as an uplink resource. In some other cases, the respective time resources 402 may be allocated for downlink signaling and may be referred to as a downlink resources. In yet other cases, the respective time resource 402 may be divided into uplink resources and downlink resources across frequency resources. For example, different sub-bands in a frequency band may be allocated for an uplink transmission and a downlink transmission, such that an uplink transmission and downlink transmission occur simultaneously or concurrently in a time resource 402.

**[0133]** An uplink sub-band 404 may split the bandwidth into one or more sub-bands. For example, an uplink sub-band 404 may be split into two or three sub-bands, one uplink sub-band 404 adjacent to one or more downlink sub-bands 406. The bandwidth may be configured as downlink (e.g., via a TDD configuration, as described with reference to Figure 3), and then the uplink sub-band splits the bandwidth (e.g., indicated by an SBFD sub-band configuration). However, the remaining downlink resources are also referred to as sub-bands. For example, an uplink sub-band 404 may be configured in a downlink bandwidth, two downlink sub-bands 406 and an uplink sub-band 404 may be configured separately, and/or two downlink sub-bands 406 may be configured in an uplink bandwidth.

**[0134]** An uplink sub-band 404 and a downlink sub-band 406 may be separated by a frequency resource that represents a gap between the uplink sub-band 404 and the downlink sub-band 406, referred to as a guard band 408. In some examples, a guard band 408 may be configured explicitly, or determined implicitly, between two adjacent sub-bands, particularly between adjacent sub-bands

of different directions (e.g., between a downlink sub-band 406 and an uplink sub-band 404). The guard band 408 may be configured or determined as a numerical quantity of PRBs on which a UE is expected neither to transmit nor to receive a signal. In some examples, a wireless communications system may be half-duplex in nature (e.g., a wireless transceiver may either transmit or receive through a same antenna at a time, but not both simultaneously). However, with advanced duplexing schemes (e.g., SBFD), either or both the NE and the UE may employ advanced duplexing schemes to communicate in both downlink and uplink simultaneously.

**[0135]** In variations, the UE may receive a signal, such as a CSI-RS, on a part of the bandwidth, such as one or more downlink sub-bands 406, while refraining from using and/or monitoring the rest of the bandwidth. This is in contrast with a configuration of CSI-RS or other reference signals that are configured either as wideband (e.g., occupying the whole bandwidth) or narrowband within a semi-static and/or static contiguous sub-band.

**[0136]** In some examples, the NE may indicate a periodicity 410 over which a pattern of uplink resources and downlink resources are applied. For example, the periodicity 410 may be any numerical quantity of slots and/or symbols over which a pattern of uplink resources and downlink resources is applied. For SBFD, the pattern may change and/or may be consistent for a duration. That is, the pattern may be periodic, aperiodic, and/or dynamically updated. Although Figure 3 illustrates a periodicity 410 of 6 time resources 402 with a pattern that is not repeated, the periodicity 410 may be any numerical quantity of time resources 402 and/or may be repeated. Additionally, or alternatively, the pattern may include any numerical quantity of uplink resources and/or downlink resources. During the uplink resources, a UE may transmit signaling to an NE, while during the downlink resources, a UE may receive signaling from an NE.

**[0137]** **Figure 5** illustrates an example of a configuration diagram 500 in accordance with aspects of the present disclosure. In some examples, the configuration diagram 500 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, and/or the resource diagram 400. For example, the configuration diagram 500 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The configuration diagram 500 may illustrate an example of an explicit configuration of a CSI-RS.

**[0138]** In some examples, an NE may transmit CSI-RS configuration signaling to a UE, which may include an information element and/or other configuration information that indicates one or more sub-bands for measuring the CSI-RS. For example, the NE may configure the UE with CSI reporting and an associated CSI-RS resource by sending information elements with the format illustrated in Figure 5 to the UE. For example, the information element may indicate one or more frequency bands using one or more parameters defined in the information element (e.g., *freqBand*, *freqBand2*, etc.). In response, if the UE receives the optional parameter *freqBand2*, then the UE performs the measurement on CSI-RS resources indicated by both *freqBand* and *freqBand2*. Although two frequency band parameters are illustrated, the information element format may include any numerical quantity of frequency band parameters.

**[0139]** **Figure 6** illustrates an example of a configuration diagram 600 in accordance with aspects of the present disclosure. In some examples, the configuration diagram 600 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, and/or the configuration diagram 500. For example, the configuration diagram 600 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The configuration diagram 600 may illustrate an example of an explicit configuration of a CSI-RS.

**[0140]** In some examples, an NE may transmit CSI-RS configuration signaling to a UE, which may include an information element and/or other configuration information that indicates one or more sub-bands for measuring the CSI-RS. For example, the NE may configure the UE with CSI reporting and an associated CSI-RS resource by sending IEs with the format illustrated in Figure 6 to the UE, which may be referred to as a CSI-RS resource mapping information element. For example, the information element may indicate a frequency band set (e.g., *freqBandSet*) with one or more parameters defining the frequency band set. The parameters may include a size of the set (e.g., SIZE(1… *maxNrofCSI-FrequencyOccupation*)). In response, if the UE receives the optional parameter *freqBandSet*, then the UE may neglect the parameter *freqBand* and perform the measurement on CSI-RS resources indicated by the set of sub-bands indicated by *freqBandSet*.

**[0141]** Additionally, or alternatively, the NE may transmit an L1 and/or L2 message to the UE indicating a subset of the sub-bands configured by the parameter *freqBandSet*. The indication may be a bitmap in which M bits are associated with M sub-bands indicated by the parameter

*freqBandSet*. The bitmap may be of length M, or alternatively, the bitmap may be longer, in which case the first M bits or the last M bits may be taken into consideration and the rest of the bits are neglected (e.g., ignored) by the UE. The parameter *maxNrofCSI-FrequencyOccupation* indicates the maximum of M. In response, for respective sub-bands in the set of M sub-bands, the UE includes the CSI-RS resources confined within the sub-band if an associated bit in the bitmap takes a first value (e.g., '1') and excludes the sub-band if the associated bit in the bitmap takes a second value (e.g., '0').

**[0142]** **Figure 7** illustrates an example of configuration diagram 700 in accordance with aspects of the present disclosure. In some examples, the configuration diagram 700 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, the configuration diagram 500, and/or the configuration diagram 600. For example, the configuration diagram 700 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The configuration diagram 700 may illustrate an example of an explicit configuration of a CSI-RS.

**[0143]** In some examples, an NE may transmit CSI-RS configuration signaling to a UE, which may include an information element and/or other configuration information that indicates one or more sub-bands for measuring the CSI-RS. For example, the NE may configure the UE with CSI reporting and an associated CSI-RS resource by sending configuration information with the format illustrated in Figure 7 to the UE. For example, the configuration information may indicate a numerical quantity of RBs per sub-band as a parameter in the configuration information (e.g., *nrofRBsPerSubband*). That is, the NE may configure the UE with a configuration including the parameter *freqBand* and an integer parameter *nrofRBsPerSub-band* that indicates N = the numerical quantity of PRBs per sub-band. Additionally, or alternatively, the NE transmits an L1 and/or L2 message to the UE indicating a subset of the sub-bands, where respective sub-bands have the bandwidth of N PRBs. The indication may be a bitmap in which M bits are associated with M sub-bands. The maximum of the numerical quantity of sub-bands may be preconfigured or defined and/or obtained by dividing *nrofRBs* (e.g., in *freqBand*) to N (e.g., indicated by *nrofRBsPerSub-band*). In response, for respective sub-bands in the set of M sub-bands, the UE includes the CSI-RS

resources confined within the sub-band if an associated bit in the bitmap takes a first value (e.g., ‘1’) and excludes the sub-band if the associated bit in the bitmap takes a second value (e.g., ‘0’).

**[0144]** **Figure 8** illustrates an example of a resource diagram 800 in accordance with aspects of the present disclosure. In some examples, the resource diagram 800 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, the configuration diagram 500, the configuration diagram 600, and/or the configuration diagram 700. For example, the resource diagram 800 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The resource diagram 800 may illustrate an example of indexing techniques for a sub-band for a CSI-RS.

**[0145]** In some examples, a BWP, CC, and/or a frequency band may include a CSI-RS frequency band. A CSI-RS frequency band may include one or more frequency resources over which a CSI-RS may be transmitted. In some cases, the BWP, CC, and/or frequency band may be divided into one or more sub-bands (e.g., M sub-bands), including the sub-band 0, the sub-band 1, and/or the sub-band M-1. In variations, the UE may determine a first sub-band to include the first N PRBs in a frequency band configuration (e.g., from Figures 5 through 7, *freqBand*), the second sub-band to include the second N PRBs in the frequency band configuration, and so on. The UE numbers or indexes the PRBs for this purpose by starting from the PRB indicated by the parameter *startingRB*.

**[0146]** **Figure 9** illustrates an example of a resource diagram 900 in accordance with aspects of the present disclosure. In some examples, the resource diagram 900 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, the configuration diagram 500, the configuration diagram 600, the configuration diagram 700, and/or the resource diagram 800. For example, the resource diagram 900 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The resource diagram 900 may illustrate an example of indexing techniques for a sub-band for a CSI-RS.

**[0147]** In some examples, a BWP, CC, and/or a frequency band may include a CSI-RS frequency band. A CSI-RS frequency band may include one or more frequency resources over

which a CSI-RS may be transmitted. In some cases, the BWP, CC, and/or frequency band may be divided into one or more sub-bands (e.g., M sub-bands), including the sub-band 0, the sub-band 1, the sub-band 2, and/or the sub-band M-1. In variations, the UE may determine sub-band boundaries with respect to a first PRB in a band, carrier, CC, BWP, or the like. Then, a first sub-band associated with the first bit in the bitmap is determined the sub-band that includes the PRB indicated by an indicated starting RB (e.g., by a parameter *startingRB*), a second sub-band associated with the second bit is determined the sub-band after the first sub-band, and so on.

**[0148]** **Figure 10** illustrates an example of a configuration diagram 1000 in accordance with aspects of the present disclosure. In some examples, the configuration diagram 1000 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, the configuration diagram 500, the configuration diagram 600, the configuration diagram 700, the resource diagram 800, and/or the resource diagram 900. For example, the configuration diagram 1000 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The configuration diagram 1000 may illustrate an example of an explicit configuration of a CSI-RS.

**[0149]** In some examples, an NE may transmit CSI-RS configuration signaling to a UE, which may include an information element and/or other configuration information that indicates one or more sub-bands for measuring the CSI-RS. For example, the NE may configure the UE with CSI reporting and an associated CSI-RS resource by sending configuration information with the format illustrated in Figure 10 to the UE. For example, the configuration information may indicate one or more parameters indicating a frequency band set in a resource mapping information element. The NE may configure the UE with the parameter *nrofRBsPerSub-band* via another configuration information element or indicate a value of N PRBs per sub-band and/or RBG via an L1 and/or L2 message to the UE.

**[0150]** In some cases, the NE configures or indicates a set of sub-bands to include and/or exclude when determining the PRBs on which CSI-RS resources are used to measure CSI. By extension, the NE may configure or indicate multiple sets of sub-bands, where respective sets of sub-bands are associated with a CSI report or a CSI value in the CSI report (e.g., for if a first CSI value obtained by measuring a first set of sub-bands is different from a second CSI value obtained by measuring a second set of sub-bands). A cause for a difference in measurements is frequency

selectivity of the wireless channel. Additionally, or alternatively, the difference may be caused by different antenna configurations used by the NE to transmit CSI-RS on a sub-band in the case of SBFD. Thus, the NE may determine CSI values obtained by measuring CSI-RS in different sub-band combinations, such that the NE determines which sub-bands to configure or indicate for SBFD operation. This method may be useful not for dynamic SBFD where the NE may indicate different sub-bands for SBFD dynamically, but also for semi-static SBFD where the NE may modify the SBFD sub-band configuration.

**[0151]** In some cases, the NE configures the UE with a CSI-RS-ResourceMapping information element illustrated in Figure 10. The UE may determine that an optional parameter *freqBandSets* indicates a set of K parameters of type *freqBandSet*. Respective parameters of type *freqBandSet* indicate a set and/or list of M sub-bands, where a sub-band (e.g., each sub-band) in the M sub-bands includes N PRBs indicated by a *startingRB* and a *nrofRBs*. In some cases, the value of N may be different in each sub-band since the values of *startingRB* and a *nrofRBs* may be different for different sub-bands. Similarly, the value of M may be different in each of the K sub-band sets. The UE may use a first sub-band set of the K sub-band sets to determine frequency resources (e.g., PRBs) of the CSI-RS for measuring and obtaining a first CSI value, a second sub-band set to determine frequency resources (e.g., PRBs) of the CSI-RS for measuring and obtaining a second CSI value, and so on. Then, the UE may send one or more CSI reports to the NE, where each CSI report may include one or more of the CSI values. Although this example can be realized via multiple CSI-RS resource configurations (e.g., K configurations), an advantage of the realization via K sub-band sets indicated by or associated with one CSI-RS resource configuration is reducing complexity, because the UE maintains a smaller numerical quantity of configurations for a same task.

**[0152]** **Figure 11** illustrates an example of a resource diagram 1100 in accordance with aspects of the present disclosure. In some examples, the resource diagram 1100 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, the configuration diagram 500, the configuration diagram 600, the configuration diagram 700, the resource diagram 800, the resource diagram 900, and/or the configuration diagram 1000. For example, the resource diagram 1100 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference

to Figure 1. The resource diagram 1100 may illustrate an example of CSI-RS frequency resource allocation.

**[0153]** In some examples, a BWP, CC, and/or a frequency band may include a CSI-RS frequency band. A CSI-RS frequency band 1102 may include one or more frequency resources over which a CSI-RS may be transmitted. In some cases, the CSI-RS frequency band 1102 may include one or more sub-bands, PRBs, or other frequency resources. An NE may transmit a CSI-RS according to a periodicity, such as a CSI-RS periodicity 1104. For example, the NE may transmit a CSI-RS using one or more downlink resources in a CSI-RS frequency band 1102 that includes uplink resources and downlink resources. In some cases, a UE may determine a CSI-RS frequency resources in each occurrence of a CSI-RS within a configured CSI-RS frequency band 1102. The CSI-RS frequency occurrences are separated in the time domain by a CSI-RS periodicity 1104. Each CSI-RS periodicity 1104 may be associated with a measurement occasion.

**[0154]** **Figure 12** illustrates an example of a configuration diagram 1200 in accordance with aspects of the present disclosure. In some examples, the configuration diagram 1200 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, the configuration diagram 500, the configuration diagram 600, the configuration diagram 700, the resource diagram 800, the resource diagram 900, the configuration diagram 1000, and/or the resource diagram 1100. For example, the configuration diagram 1200 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The configuration diagram 1200 may illustrate an example of antenna configurations for SBFD sub-band configurations.

**[0155]** In some examples, an NE may use a different antenna panel for transmitting signaling when operating using SBFD communication techniques. For example, to realize an SBFD scheme, the NE may employ analog and/or digital technologies that enables full-duplex operation on SBFD sub-bands. As a result, the antenna panels and configurations used for communications on SBFD symbols may be different from those used for communications on non-SBFD symbols, which may result in CSI values (e.g., including beam index values) that are different between the two types of symbols. By extension, different SBFD sub-bands or sub-band combinations may be realized by different antenna panels and configurations at the NE. The NE may then assume that channel state associated with each of the antenna panels and configurations is different, and hence measurements

obtained from different antenna panels and configurations may not be combined. Therefore, if the UE is capable of and/or configured to combine results of measurements on unidentical and/or inconsistent frequency resources, then the NE may transmit signaling indicating the combinations that may produce a valid and/or meaningful result and the combinations that may not.

**[0156]** In variations, the UE may receive one or more parameters, referred to as an *AntennaConfig*, where each of the parameters is associated with a sub-band and/or RBG combination (e.g., sub-band and/or RBG inclusion and/or exclusion combination). The values of the *AntennaConfig* parameters may have a one-to-one association with antenna panels or configurations (e.g., a first value for the parameter may indicate a first antenna panel or configuration, a second value may indicate a second antenna panel or configuration, and so on). In response, the UE may determine that the UE can combine results of measurements on sub-band and/or RBG combinations associated with identical values for the *AntennaConfig* parameter. In some examples, the parameter may be indicated via a configuration or L1 and/or L2 signaling from the NE. An example indication by an RRC configuration is illustrated in Figure 12. For example, the configuration may include an *antennaConfig* parameter that indicates a maximum number of antenna configurations (e.g., *maxNrofAntennaConfig*) for a configured frequency band set.

**[0157]** **Figure 13** illustrates an example of a configuration diagram 1300 in accordance with aspects of the present disclosure. In some examples, the configuration diagram 1300 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, the configuration diagram 500, the configuration diagram 600, the configuration diagram 700, the resource diagram 800, the resource diagram 900, the configuration diagram 1000, the resource diagram 1100, and/or the configuration diagram 1200. For example, the configuration diagram 1300 may be implemented by a UE and/or an NE, which may be an example of a UE 104 and/or an NE 102 as described with reference to Figure 1. The configuration diagram 1300 may illustrate an example of antenna configurations for SBFD sub-band configurations.

**[0158]** In some examples, an NE may use a different antenna panel for transmitting signaling when operating using SBFD communication techniques, as described with reference to Figure 12. The UE may receive one or more parameters, referred to as an *AntennaConfig*, where each of the parameters is associated with a sub-band and/or RBG combination (e.g., sub-band and/or RBG

inclusion and/or exclusion combination). An example indication by an RRC configuration is illustrated in Figure 13. For example, the configuration may include an *antennaConfig* parameter that indicates a maximum number of antenna configurations (e.g., *maxNrofAntennaConfig*) for one or more frequency band sets.

**[0159]** In variations, the parameter *AntennaConfig* is assumed to take integer values between 1 and a maximum numerical quantity of antenna configurations. Other parameter types are not precluded. Similarly, the parameter may be indicated by L1 and/or L2 signaling, for example in association with a bitmap or another indication of a sub-band inclusion and/or exclusion combination. For example, a UE may receive a CSI reporting configuration indicating a CSI-RS resource configuration. The UE receives an indication of a first set of frequency resources for the CSI-RS and an associated first value of *AntennaConfig*. Additionally, or alternatively, the UE receives an indication of a second set of frequency resources and an associated second value of *AntennaConfig*. The UE performs a first measurement on the first set of CSI-RS frequency resources to obtain a first CSI value and a second measurement on the second set of CSI-RS frequency resources to obtain a second CSI value. The UE compares the first value of *AntennaConfig* with the second value of *AntennaConfig*. If the values are the same (e.g., identical), then the UE may determine that it may combine the first CSI value and the second CSI value. If the *AntennaConfig* values are not identical, then the UE may determine not to combine the CSI values.

**[0160]** **Figure 14** illustrates an example of a signaling diagram 1400 in accordance with aspects of the present disclosure. In some examples, the signaling diagram 1400 implements aspects of the wireless communications system 100, the wireless communications system 200, the resource diagram 300, the resource diagram 400, the configuration diagram 500, the configuration diagram 600, the configuration diagram 700, the resource diagram 800, the resource diagram 900, the configuration diagram 1000, the resource diagram 1100, the configuration diagram 1200, and/or the configuration diagram 1300. The signaling diagram 1400 may illustrate an example of configuring CSI-RS resources for SBFD operation at an NE 102 and/or a UE 104. The NE 102 and the UE 104 may be examples of a UE 104 and an NE 102 as described with reference to Figures 1 through 13. Alternative examples of the following may be implemented, where some processes are performed in a different order than described or are not performed. In some cases, processes may include additional features not mentioned below, or further processes may be added.

**[0161]** In some examples, at 1402, a UE 104 may transmit capability signaling to the NE 102. The capability signaling may include one or more parameters, or other information, that indicates a capability of the UE 104 related to CSI-RS resource allocation for SBFD operation. The UE 104 may transmit the capability signaling in control signaling (e.g., uplink control information (UCI) and/or another message and/or control signaling). The UE 104 may send the capability signaling in a message dedicated for indicating the capability of the UE 104 relate to the CSI-RS resource allocation for SBFD operation and/or in another capability message that additionally, or alternatively, indicates other capability information related to the UE 104. The capability signaling may include at least one of a maximum numerical quantity of sub-bands supported by the UE 104, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in a CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the UE 104.

**[0162]** At 1404, the UE 104 may receive signaling configuring a CSI-RS transmission. For example, the signaling may indicate a set of frequency sub-bands within a CSI-RS frequency band. The signaling may be an example of control signaling (e.g., RRC signaling, a MAC-CE, a DCI message). The signaling may include one or more parameters (e.g., an information element or other control information) that indicates the set of frequency sub-bands within the CSI-RS frequency band. In variations, the respective frequency sub-bands of the set of frequency sub-bands include PRBs and/or RBGs.

**[0163]** In some examples, the signaling configuring a CSI-RS transmission includes one or more parameters that indicate respective indices of frequency sub-bands within the CSI-RS frequency band. The parameters may include an information element indicating the respective indices, an information element indicating one or more sets of indices of the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices, and/or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands

within the CSI-RS frequency band. In some cases, the signaling configuring a CSI-RS transmission indicates a semi-static frequency resource allocation for an uplink sub-band and a frequency resources allocation for the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation. That is, the SBFD resource allocation may overlap with a CSI-RS resource allocation. The UE may determine the set of frequency sub-bands within the CSI-RS frequency band implicitly, such as by using the semi-static frequency resource allocation and the frequency resources allocation for the CSI-RS frequency band. In some examples, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. In some cases, the plurality of frequency sub-bands within the CSI-RS frequency band has a guard band that satisfies a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0164]** At 1406, the UE 104 may receive signaling configuring a CSI report. For example, the CSI report may be for reporting one or more measurements of a CSI-RS. In some examples, the signaling configuring the CSI report indicates for the CSI report to include a measurement (e.g., a CSI-RS measurement), an indication that the measurement is obtained by measuring an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the signaling configuring the CSI report indicates for the CSI report to include one or more CSI values obtained from CSI measurements, an error status of one or more monitoring occasions scheduled for a CSI-RS, an indication of one or more frequency resources for which the CSI values are obtained, or a measurement technique for obtaining the CSI measurements.

**[0165]** At 1408, the UE 104 may receive one or more dynamic indications from the NE 102. For example, the dynamic indications may include an indication of a bitmap, or any other type of sub-band inclusion and/or exclusion indication. In some cases, the indication of the bitmap or other inclusions and/or exclusion indication of the sub-bands may be included in the signaling configuring the CSI-RS at 1404. The NE 102 may transmit one or more dynamic L1 and/or L2 signaling (e.g., in addition to the signaling at 1404 and 1406).

**[0166]** At 1410, the NE 102 (e.g., or another device) may transmit one or more CSI-RSs to the UE 104. For example, the NE 102 may transmit the CSI-RSs in a CSI frequency band and using one

or more time resources allocated for the CSI-RS transmission. The NE 102 may transmit the CSI-RSs in one or more monitoring occasions (e.g., according to a CSI-RS transmission periodicity).

**[0167]** At 1412, the UE 104 may selectively perform one or more CSI-RS measurements on a subset of frequency sub-bands. For example, the UE 104 may selectively perform at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band according to the first signaling and the second signaling. In some examples, the UE 104 may receive signaling that indicates the subset of frequency sub-bands. For example, the NE 102 may include an indication of the subset of frequency sub-bands in the signaling configuring the CSI report and/or in other signaling. The subset of frequency sub-bands may include an initial or first occurrence of the CSI-RS.

**[0168]** In some cases, the UE 104 performs the measurements on the subset of frequency sub-bands based on a determination that the measurements on the subset of frequency sub-bands are valid. The UE may determine that the measurements are valid by comparing a bandwidth of the frequency sub-bands to a minimum bandwidth for the measurement. If the bandwidth satisfies a threshold value (e.g., the minimum bandwidth), then the UE may determine the measurements are valid. If the bandwidth fails to satisfy a threshold value (e.g., the minimum bandwidth), then the UE may determine the measurements are invalid. Additionally, or alternatively, the UE 104 may determine that the measurements are valid by comparing a guard band separating respective sub-bands in the subset of frequency sub-bands and uplink SBFD sub-bands to a threshold value. If the guard band satisfies the threshold value (e.g., a minimum value), then the UE 104 may determine that the measurements are valid. If the guard band fails to satisfy the threshold value (e.g., a minimum value), then the UE 104 may determine that the measurements are invalid. Additionally, or alternatively, the UE 104 may determine the measurements are valid if the measurements on the subset of frequency sub-bands are compatible with a capability of the UE 104 (e.g., the capability reported at 1402) and invalid if the measurements on the subset of frequency sub-bands are not compatible with a capability of the UE 104.

**[0169]** In some other cases, the UE 104 refrains from performing the measurements on the subset of frequency sub-bands and/or performs a portion of the measurements on the frequency sub-bands based on a determination that the measurements on the subset of frequency sub-bands are invalid or partially valid. In some cases, the UE 104 performs the measurements for a time period,

for a threshold numerical quantity of measurements, for a threshold numerical quantity of measurement occasions, based on a start time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, based on an end time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, or any combination thereof.

**[0170]** In some examples, the UE 104 receives signaling that indicates an additional subset of frequency sub-bands of a set of frequency sub-bands scheduled for an occurrence of a CSI-RS. The UE 104 may selectively perform additional measurements on the additional subset of frequency sub-bands if the additional measurements are valid. In some examples, the UE may combine the measurement and the additional measurement if the measurements are associated with a same antenna panel (e.g., as indicated in control signaling and as described with reference to Figures 12 and 13). In some examples, the UE 104 may receive signaling including one or more parameters that indicate an antenna panel used to transmit a CSI-RS for respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0171]** At 1414, the UE 104 may transmit a CSI report to the NE 102. For example, the UE 104 may use the signaling configuring the CSI report to determine the information to include in the CSI report. If the UE performs the measurement at 1412, then the UE 104 may include one or more CSI-RS measurements in the CSI report.

**[0172]** In some examples, the different steps described for the example implementations, in the text and in the flowcharts, may be permuted. Each configuration may be provided by one or more configurations in practice. An earlier configuration may provide a subset of parameters while a later configuration may provide another subset of parameters. Additionally, or alternatively, a later configuration may override values provided by an earlier configuration or a pre-configuration. A configuration may be provided by Xn signaling between RAN nodes and/or NG signaling between RAN nodes, RRC signaling, a MAC signaling, a physical layer signaling, such as a DCI message, any combination thereof, or other methods. A configuration may include a pre-configuration, or a semi-static configuration provided by the standard, by the vendor, and/or by the network and/or operator (e.g., OAM). Each parameter value received through configuration or indication may override previous values for a similar parameter.

**[0173]** L1 and/or L2 control signaling may refer to control signaling in layer 1 (e.g., physical layer) or layer 2 (e.g., data link layer). Particularly, an L1 and/or L2 control signaling may refer to an L1 control signaling such as a DCI message or a UCI message, an L2 control signaling such as a MAC message, or any combination thereof. A format and an interpretation of an L1 and/or L2 control signaling may be determined by the standard, a configuration, other control signaling, or any combination thereof.

**[0174]** Reference is frequently made, in the present disclosure, to a message or an information element. In some examples, an information element refers to a configuration at layer 3 and higher. An information element may be included in a message from one layer to another layer or from one entity to another entity. Additionally, or alternatively, another information element may include an information element. As used herein, the terms ‘information element’ and ‘message’ may be used interchangeably when the message includes the information element directly or indirectly. Any parameter discussed in this disclosure may appear, in practice, as a linear function of that parameter in signaling or specifications.

**[0175]** In the present disclosure, reference is frequently made to beam indication. In practice, according to a standard specification, a beam indication may refer to an indication of a reference signal by an ID or indicator, a resource associated with a reference signal, a spatial relation information including information of a reference signal or a reciprocal of a reference signal (in the case of beam correspondence). Despite frequent reference to specific types of reference signals such as CSI-RS, SRS, SSB, or the like, systems and methods are not limited in scope to the specific reference signals. In various realizations, other types of reference signals may be used, which may include reference signals specified for the purposes pursued in the present disclosure. Throughout the specifications, the terms “parameter” and a “value” for the parameter may be used interchangeably. A parameter may be a sequence/array of parameters in various realizations.

**[0176]** **Figure 15** illustrates an example of a UE 1500 in accordance with aspects of the present disclosure. The UE 1500 may include a processor 1502, a memory 1504, a controller 1506, and a transceiver 1508. The processor 1502, the memory 1504, the controller 1506, or the transceiver 1508, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be

coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

**[0177]** The processor 1502, the memory 1504, the controller 1506, or the transceiver 1508, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

**[0178]** The processor 1502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 1502 may be configured to operate the memory 1504. In some other implementations, the memory 1504 may be integrated into the processor 1502. The processor 1502 may be configured to execute computer-readable instructions stored in the memory 1504 to cause the UE 1500 to perform various functions of the present disclosure.

**[0179]** The memory 1504 may include volatile or non-volatile memory. The memory 1504 may store computer-readable, computer-executable code including instructions when executed by the processor 1502 cause the UE 1500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the memory 1504 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

**[0180]** In some implementations, the processor 1502 and the memory 1504 coupled with the processor 1502 may be configured to cause the UE 1500 to perform one or more of the functions described herein (e.g., executing, by the processor 1502, instructions stored in the memory 1504). For example, the processor 1502 may support wireless communication at the UE 1500 in accordance with examples as disclosed herein. The UE 1500 may be configured to or operable to support a means for receiving a first signaling configuring a CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, receiving a second signaling

configuring a CSI report associated with the CSI-RS, selectively performing at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band based on the first signaling and the second signaling, and transmitting a third signaling including the CSI report based on the second signaling.

**[0181]** Additionally, the UE 1500 may be configured to support any one or combination of receiving a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the CSI-RS. Additionally, or alternatively, to selectively perform the at least one measurement the UE 1500 may be configured to support performing the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is valid, and where the CSI report includes the at least one measurement. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands satisfying a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands being compatible with a capability of the UE 1500. Additionally, or alternatively, to selectively perform the at least one measurement the UE 1500 may be configured to support refraining from performing the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is invalid, and where the CSI report includes an indication that the subset of frequency sub-bands is invalid. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands failing to satisfy a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands not being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands not being compatible with a capability of the UE 1500.

**[0182]** Additionally, or alternatively, the UE 1500 may be configured to support receiving a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the CSI-RS, and selectively performing at least one additional measurement on the additional subset of frequency sub-bands based on the first signaling, the second signaling, and a determination that the at least one additional measurement is

valid. Additionally, or alternatively, the determination that the additional subset of frequency sub-bands is valid is based on at least one of the additional subset of frequency sub-bands satisfying a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one additional measurement on the additional subset of frequency sub-bands being compatible with a capability of the UE 1500. Additionally, or alternatively, the UE 1500 may be configured to support combining the at least one measurement and the at least one additional measurement based on the at least one measurement being associated with a same antenna panel as the at least one additional measurement.

**[0183]** Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation, and further including determine the set of frequency sub-bands within the CSI-RS frequency band based on the semi-static frequency resource allocation and the frequency resources allocation associated with the CSI-RS frequency band. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0184]** Additionally, or alternatively, to selectively perform the at least one measurement the UE 1500 may be configured to support performing the at least one measurement for a time period,

for a threshold numerical quantity of measurements, for a threshold numerical quantity of measurement occasions, based on a start time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, based on an end time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, or any combination thereof. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement.

**[0185]** Additionally, or alternatively, the UE 1500 may be configured to support receiving a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the UE 1500 may be configured to support transmitting a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the UE 1500, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the UE. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

**[0186]** Additionally, or alternatively, the UE 1500 may support at least one memory (e.g., the memory 1504) and at least one processor (e.g., the processor 1502) coupled with the at least one

memory and configured to cause the UE to receive a first signaling configuring a CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, receive a second signaling configuring a CSI report associated with the CSI-RS, selectively perform at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band based on the first signaling and the second signaling, and transmit a third signaling including the CSI report based on the second signaling.

**[0187]** Additionally, the UE 1500 may be configured to support any one or combination of the at least one processor is configured to receive a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the CSI-RS. Additionally, or alternatively, to selectively perform the at least one measurement, the at least one processor is configured to perform the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is valid, and where the CSI report includes the at least one measurement. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands satisfying a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands being compatible with a capability of the UE 1500. Additionally, or alternatively, to selectively perform the at least one measurement, the at least one processor is configured to refrain from performing the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is invalid, and where the CSI report includes an indication that the subset of frequency sub-bands is invalid. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands failing to satisfy a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands not being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands not being compatible with a capability of the UE 1500.

**[0188]** Additionally, or alternatively, the at least one processor is configured to receive a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the CSI-RS, and selectively perform at least one additional

measurement on the additional subset of frequency sub-bands based on the first signaling, the second signaling, and a determination that the at least one additional measurement is valid. Additionally, or alternatively, the determination that the additional subset of frequency sub-bands is valid is based on at least one of the additional subset of frequency sub-bands satisfying a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one additional measurement on the additional subset of frequency sub-bands being compatible with a capability of the UE 1500. Additionally, or alternatively, the at least one processor is configured to combine the at least one measurement and the at least one additional measurement based on the at least one measurement being associated with a same antenna panel as the at least one additional measurement.

**[0189]** Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation, and where the at least one processor is configured to determine the set of frequency sub-bands within the CSI-RS frequency band based on the semi-static frequency resource allocation and the frequency resources allocation associated with the CSI-RS frequency band. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard

band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0190]** Additionally, or alternatively, to selectively perform the at least one measurement, the at least one processor is configured to perform the at least one measurement for a time period, for a threshold numerical quantity of measurements, for a threshold numerical quantity of measurement occasions, based on a start time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, based on an end time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, or any combination thereof. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement.

**[0191]** Additionally, or alternatively, the at least one processor is configured to receive a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the at least one processor is configured to transmit a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the UE, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna

panels supported by the UE. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

**[0192]** The controller 1506 may manage input and output signals for the UE 1500. The controller 1506 may also manage peripherals not integrated into the UE 1500. In some implementations, the controller 1506 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 1506 may be implemented as part of the processor 1502.

**[0193]** In some implementations, the UE 1500 may include at least one transceiver 1508. In some other implementations, the UE 1500 may have more than one transceiver 1508. The transceiver 1508 may represent a wireless transceiver. The transceiver 1508 may include one or more receiver chains 1510, one or more transmitter chains 1512, or a combination thereof.

**[0194]** A receiver chain 1510 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 1510 may include one or more antennas to receive a signal over the air or wireless medium. The receiver chain 1510 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 1510 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 1510 may include at least one decoder for decoding the demodulated signal to receive the transmitted data.

**[0195]** A transmitter chain 1512 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 1512 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature AM (QAM). The transmitter chain 1512 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 1512 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

**[0196]** **Figure 16** illustrates an example of a processor 1600 in accordance with aspects of the present disclosure. The processor 1600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 1600 may include a controller 1602 configured to perform various operations in accordance with examples as described herein. The processor 1600 may optionally include at least one memory 1604, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 1600 may optionally include one or more arithmetic-logic units (ALUs) 1606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

**[0197]** The processor 1600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 1600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

**[0198]** The controller 1602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 1600 to cause the processor 1600 to support various operations in accordance with examples as described herein. For example, the controller 1602 may operate as a control unit of the processor 1600, generating control signals that manage the operation of various components of the processor 1600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

**[0199]** The controller 1602 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 1604 and determine subsequent instruction(s) to be executed to cause the processor 1600 to support various operations in accordance with examples as described herein. The controller 1602 may be configured to track memory addresses of instructions associated with

the memory 1604. The controller 1602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 1602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 1600 to cause the processor 1600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 1602 may be configured to manage flow of data within the processor 1600. The controller 1602 may be configured to control transfer of data between registers, ALUs 1606, and other functional units of the processor 1600.

**[0200]** The memory 1604 may include one or more caches (e.g., memory local to or included in the processor 1600 or other memory), such as RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 1604 may reside within or on a processor chipset (e.g., local to the processor 1600). In some other implementations, the memory 1604 may reside external to the processor chipset (e.g., remote to the processor 1600).

**[0201]** The memory 1604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 1600, cause the processor 1600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 1602 and/or the processor 1600 may be configured to execute computer-readable instructions stored in the memory 1604 to cause the processor 1600 to perform various functions. For example, the processor 1600 and/or the controller 1602 may be coupled with or to the memory 1604, the processor 1600, and the controller 1602, and may be configured to perform various functions described herein. In some examples, the processor 1600 may include multiple processors and the memory 1604 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

**[0202]** The one or more ALUs 1606 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 1606 may reside within or on a processor chipset (e.g., the processor 1600). In some other implementations, the one or more ALUs 1606 may reside external to the processor chipset (e.g., the processor 1600). One or more ALUs 1606 may perform one or more computations such as addition,

subtraction, multiplication, and division on data. For example, one or more ALUs 1606 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 1606 may be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 1606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 1606 to handle conditional operations, comparisons, and bitwise operations.

**[0203]** The processor 1600 may support wireless communication in accordance with examples as disclosed herein. The processor 1600 may be configured to or operable to support at least one controller (e.g., the controller 1602) coupled with at least one memory (e.g., the memory 1604) and configured to cause the processor to receive a first signaling configuring a CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, receive a second signaling configuring a CSI report associated with the CSI-RS, selectively perform at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band based on the first signaling and the second signaling, and transmit a third signaling including the CSI report based on the second signaling.

**[0204]** Additionally, the processor 1600 may be configured to or operable to support any one or combination of the at least one controller is configured to cause the processor to receive a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the CSI-RS. Additionally, or alternatively, to selectively perform the at least one measurement, the at least one controller is configured to cause the processor to perform the at least one measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is valid, and where the CSI report includes the at least one measurement. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands satisfying a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands being compatible with a capability of the processor. Additionally, or alternatively, to selectively perform the at least one measurement, the at least one controller is configured to cause the processor to refrain from performing the at least one

measurement on the subset of frequency sub-bands based on a determination that the at least one measurement on the subset of frequency sub-bands is invalid, and where the CSI report includes an indication that the subset of frequency sub-bands is invalid. Additionally, or alternatively, the determination is based on at least one of the subset of frequency sub-bands failing to satisfy a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands not being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one measurement on the subset of frequency sub-bands not being compatible with a capability of the processor.

**[0205]** Additionally, or alternatively, the at least one controller is configured to cause the processor to receive a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the CSI-RS, and selectively perform at least one additional measurement on the additional subset of frequency sub-bands based on the first signaling, the second signaling, and a determination that the at least one additional measurement is valid. Additionally, or alternatively, the determination that the additional subset of frequency sub-bands is valid is based on at least one of the additional subset of frequency sub-bands satisfying a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands being separated from an SBFD uplink sub-band by a minimum guard band, or the at least one additional measurement on the additional subset of frequency sub-bands being compatible with a capability of the processor. Additionally, or alternatively, the at least one controller is configured to cause the processor to combine the at least one measurement and the at least one additional measurement based on the at least one measurement being associated with a same antenna panel as the at least one additional measurement. Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the

CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band.

**[0206]** Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation, and where the at least one controller is configured to cause the processor to determine the set of frequency sub-bands within the CSI-RS frequency band based on the semi-static frequency resource allocation and the frequency resources allocation associated with the CSI-RS frequency band. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band. Additionally, or alternatively, to selectively perform the at least one measurement, the at least one controller is configured to cause the processor to perform the at least one measurement for a time period, for a threshold numerical quantity of measurements, for a threshold numerical quantity of measurement occasions, based on a start time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, based on an end time for measuring the subset of frequency sub-bands within the CSI-RS frequency band, or any combination thereof.

**[0207]** Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement. Additionally, or alternatively, the at least one controller is configured to cause the processor to receive a fourth signaling including at least one parameter

associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0208]** Additionally, or alternatively, the at least one controller is configured to cause the processor to transmit a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the processor, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the processor. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

**[0209]** **Figure 17** illustrates an example of an NE 1700 in accordance with aspects of the present disclosure. The NE 1700 may include a processor 1702, a memory 1704, a controller 1706, and a transceiver 1708. The processor 1702, the memory 1704, the controller 1706, or the transceiver 1708, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

**[0210]** The processor 1702, the memory 1704, the controller 1706, or the transceiver 1708, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

**[0211]** The processor 1702 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some

implementations, the processor 1702 may be configured to operate the memory 1704. In some other implementations, the memory 1704 may be integrated into the processor 1702. The processor 1702 may be configured to execute computer-readable instructions stored in the memory 1704 to cause the NE 1700 to perform various functions of the present disclosure.

**[0212]** The memory 1704 may include volatile or non-volatile memory. The memory 1704 may store computer-readable, computer-executable code including instructions when executed by the processor 1702 cause the NE 1700 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as the memory 1704 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

**[0213]** In some implementations, the processor 1702 and the memory 1704 coupled with the processor 1702 may be configured to cause the NE 1700 to perform one or more of the functions described herein (e.g., executing, by the processor 1702, instructions stored in the memory 1704). For example, the processor 1702 may support wireless communication at the NE 1700 in accordance with examples as disclosed herein. The NE 1700 may be configured to or operable to support a means for transmitting, to a UE, a first signaling configuring at least one CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, transmitting, to the UE, a second signaling configuring a CSI report associated with the at least one CSI-RS, transmitting the at least one CSI-RS based on the first signaling, and receiving a third signaling including the CSI report based on the second signaling, the CSI report is based on at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0214]** Additionally, the NE 1700 may be configured to or operable to support any one or combination of the method further including transmitting a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the at least one CSI-RS. Additionally, or alternatively, the subset of frequency sub-bands satisfies a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands are separated from an SBFD uplink sub-band by a minimum guard

band, the at least one measurement on the subset of frequency sub-bands is compatible with a capability of the UE, or any combination thereof. Additionally, or alternatively, the NE 1700 may be configured to or operable to support transmitting a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the at least one CSI-RS, and where the additional subset of frequency sub-bands corresponds to at least one additional measurement on the additional subset of frequency sub-bands. Additionally, or alternatively, the additional subset of frequency sub-bands satisfies a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands are separated from an SBFD uplink sub-band by a minimum guard band, the at least one additional measurement on the additional subset of frequency sub-bands is compatible with a capability of the UE, or any combination thereof.

**[0215]** Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0216]** Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is

obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement. Additionally, or alternatively, the NE 1700 may be configured to or operable to support transmitting a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the NE 1700 may be configured to or operable to support receiving a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the UE, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the UE. Additionally, or alternatively, respective frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

**[0217]** Additionally, or alternatively, the NE 1700 may support at least one memory (e.g., the memory 1704) and at least one processor (e.g., the processor 1702) coupled with the at least one memory and configured to cause the NE to transmit, to a UE, a first signaling configuring at least one CSI-RS, the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band, transmit, to the UE, a second signaling configuring a CSI report associated with the at least one CSI-RS, transmit the at least one CSI-RS based on the first signaling, and receive a third signaling including the CSI report based on the second signaling, the CSI report is based on at least

one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0218]** Additionally, the NE 1700 may be configured to support any one or combination of the at least one processor is configured to cause the NE 1700 to transmit a fourth signaling that indicates the subset of frequency sub-bands, and where the subset of frequency sub-bands corresponds to an initial occurrence of the at least one CSI-RS. Additionally, or alternatively, the subset of frequency sub-bands satisfies a minimum bandwidth for the at least one measurement, respective sub-bands in the subset of frequency sub-bands are separated from an SBFD uplink sub-band by a minimum guard band, the at least one measurement on the subset of frequency sub-bands is compatible with a capability of the UE, or any combination thereof.

**[0219]** Additionally, or alternatively, the at least one processor is configured to cause the NE 1700 to transmit a fourth signaling that indicates an additional subset of frequency sub-bands of the set of frequency sub-bands associated with an occurrence of the at least one CSI-RS, and where the additional subset of frequency sub-bands corresponds to at least one additional measurement on the additional subset of frequency sub-bands. Additionally, or alternatively, the additional subset of frequency sub-bands satisfies a minimum bandwidth for the at least one additional measurement, respective sub-bands in the additional subset of frequency sub-bands are separated from an SBFD uplink sub-band by a minimum guard band, the at least one additional measurement on the additional subset of frequency sub-bands is compatible with a capability of the UE, or any combination thereof. Additionally, or alternatively, the first signaling includes at least one parameter that indicates respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band.

**[0220]** Additionally, or alternatively, the at least one parameter includes one or more of an information element indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, an information element indicating one or more sets of indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, a bitmap indicating the respective indices corresponding to the set of frequency sub-bands within the CSI-RS frequency band, or a parameter indicating a numerical quantity of PRBs per sub-band of the set of frequency sub-bands within the CSI-RS frequency band. Additionally, or alternatively, the first signaling indicates a semi-static frequency resource allocation associated with at least one

uplink sub-band and a frequency resources allocation associated with the CSI-RS frequency band that overlaps with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are non-overlapping with the at least one uplink sub-band associated with the semi-static frequency resource allocation. Additionally, or alternatively, the set of frequency sub-bands within the CSI-RS frequency band are associated with a threshold guard band value between the set of frequency sub-bands within the CSI-RS frequency band and the at least one uplink sub-band.

**[0221]** Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of the at least one measurement, an indication that the at least one measurement is obtained by measuring at least one of an SBFD time resource or a non-SBFD time resource, an indication of the subset of frequency sub-bands, or an indication of an error status of the at least one measurement. Additionally, or alternatively, the second signaling indicates for the CSI report to include at least one of one or more CSI values associated with a set of CSI measurements, an error status corresponding to one or more monitoring occasions associated with the CSI-RS, an indication of one or more frequency resources associated with the one or more CSI values, or a measurement technique for obtaining the set of CSI measurements, and where the set of CSI measurements includes the at least one measurement. Additionally, or alternatively, the at least one processor is configured to cause the NE 1700 to transmit a fourth signaling including at least one parameter associated with a value that indicates an antenna panel corresponding to respective sub-bands of the set of frequency sub-bands within the CSI-RS frequency band.

**[0222]** Additionally, or alternatively, the at least one processor is configured to cause the NE 1700 to receive a fourth signaling that indicates at least one of a maximum numerical quantity of sub-bands supported by the UE, a maximum numerical quantity of sub-band combinations, a maximum numerical quantity of sub-band combinations associated with a time period, a maximum numerical quantity of changes to a sub-band combination associated with a time period, a minimum bandwidth for the at least one measurement to be a valid measurement, a maximum numerical quantity of sub-bands for a respective measurement of the at least one measurement, a maximum numerical quantity of sub-band indications to include in the CSI report, a maximum numerical quantity of combination for a CSI value based on multiple monitoring occasions, or a maximum numerical quantity of antenna panels supported by the UE. Additionally, or alternatively, respective

frequency sub-bands of the set of frequency sub-bands include at least one of one or more PRBs or one or more RBGs.

**[0223]** The controller 1706 may manage input and output signals for the NE 1700. The controller 1706 may also manage peripherals not integrated into the NE 1700. In some implementations, the controller 1706 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 1706 may be implemented as part of the processor 1702.

**[0224]** In some implementations, the NE 1700 may include at least one transceiver 1708. In some other implementations, the NE 1700 may have more than one transceiver 1708. The transceiver 1708 may represent a wireless transceiver. The transceiver 1708 may include one or more receiver chains 1710, one or more transmitter chains 1712, or a combination thereof.

**[0225]** A receiver chain 1710 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 1710 may include one or more antennas to receive a signal over the air or wireless medium. The receiver chain 1710 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 1710 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 1710 may include at least one decoder for decoding the demodulated signal to receive the transmitted data.

**[0226]** A transmitter chain 1712 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 1712 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as AM, FM, or digital modulation schemes like PSK or QAM. The transmitter chain 1712 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 1712 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

**[0227]** **Figure 18** illustrates a flowchart of a method 1800 in accordance with aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, the UE may execute a set of instructions to control the function elements of the UE to perform the described functions. It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

**[0228]** At 1802, the method may include receiving a first signaling configuring a CSI-RS, where the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band. The operations of 1802 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1802 may be performed by a UE as described with reference to Figure 15.

**[0229]** At 1804, the method may include receiving a second signaling configuring a CSI report associated with the CSI-RS. The operations of 1804 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1804 may be performed by a UE as described with reference to Figure 15.

**[0230]** At 1806, the method may include selectively perform at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band based on the first signaling and the second signaling. The operations of 1806 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1806 may be performed a UE as described with reference to Figure 15.

**[0231]** At 1808, the method may include transmitting a third signaling including the CSI report based on the second signaling. The operations of 1808 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1808 may be performed a UE as described with reference to Figure 15.

**[0232]** **Figure 19** illustrates a flowchart of a method 1900 in accordance with aspects of the present disclosure. The operations of the method may be implemented by an NE as described herein. In some implementations, the NE may execute a set of instructions to control the function elements of the NE to perform the described functions. It should be noted that the method described

herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

**[0233]** At 1902, the method may include transmitting, to a UE, a first signaling configuring at least one CSI-RS, where the first signaling indicates a set of frequency sub-bands within a CSI-RS frequency band. The operations of 1902 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1902 may be performed by an NE as described with reference to Figure 17.

**[0234]** At 1904, the method may include transmitting, to the UE, a second signaling configuring a CSI report associated with the CSI-RS. The operations of 1904 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1904 may be performed by an NE as described with reference to Figure 17.

**[0235]** At 1906, the method may include transmitting the at least one CSI-RS based on the first signaling. The operations of 1906 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1906 may be performed an NE as described with reference to Figure 17.

**[0236]** At 1908, the method may include receiving a third signaling including the CSI report based on the second signaling, where the CSI report is based on at least one measurement on a subset of frequency sub-bands of the set of frequency sub-bands within the CSI-RS frequency band. The operations of 1908 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1908 may be performed an NE as described with reference to Figure 17.

**[0237]** The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.