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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

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1 Scope

The present document describes the physical layer measurements for NR.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TS 38.201: "NR; Physical Layer – General Description"

[3] 3GPP TS 38.211: "NR; Physical channels and modulation"

[4] 3GPP TS 38.212: "NR; Multiplexing and channel coding"

[5] 3GPP TS 38.213: "NR; Physical layer procedures for control channels"

[6] 3GPP TS 38.214: "NR; Physical layer procedures for data channels"

[7] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"

[8] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification"

[9] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception"

[10] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification"

[11] IEEE 802.11, Part 11: "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications, IEEE Std."

[12] 3GPP TS 38.133: "NR; Requirements for support of radio resource management"

[13] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation"

[14] 3GPP TS 38.509: "5GS; Special conformance testing functions for User Equipment (UE)"

[15] 3GPP TS 38.901: "Study on channel model for frequencies from 0.5 to 100 GHz"

[16] 3GPP TS 38.455: "NR Positioning Protocol A (NRPPa)"

[17] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access"

[18] 3GPP TS 38.305: "NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

3.2 Symbols

For the purposes of the present document, the following symbols apply:

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ARFCN	Absolute Radio-Frequency Channel Number
CLI	Cross Link Interference
CSI-RSRP	CSI Reference Signal Received Power
CSI-RSRQ	CSI Reference Signal Received Quality
E-UTRAN	Evolved UTRAN
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile communication
LBT	Listen before Talk
SRS	Sounding Reference Signal
SS-RSRP	Synchronization Signal Reference Signal Received Power
SS-RSRQ	Synchronization Signal Reference Signal Received Quality
UTRAN	Universal Terrestrial Radio Access Network

4 Control of UE/NG-RAN measurements

In this clause the general measurement control concept of the higher layers is briefly described to provide an understanding on how L1 measurements are initiated and controlled by higher layers.

With the measurement specifications L1 provides measurement capabilities for the UE and NG-RAN. These measurements can be classified in different reported measurement types: intra-frequency, inter-frequency, inter-system, traffic volume, quality and UE internal measurements.

In the L1 measurement definitions, see clause 5, the measurements are categorised as measurements in the UE or measurements in the NG-RAN.

5 Measurement capabilities for NR

5.1 UE measurement capabilities

The structure of the table defining a UE measurement quantity is shown below.

Column field	Comment
Definition	Contains the definition of the measurement.
Applicable for	States in which state(s) it shall be possible to perform this measurement. The following terms are used in the tables: RRC_IDLE; RRC_INACTIVE; RRC_CONNECTED; Intra-frequency appended to the RRC state: Shall be possible to perform in the corresponding RRC state on an intra-frequency cell; Inter-frequency appended to the RRC state: Shall be possible to perform in the corresponding RRC state on an inter-frequency cell Inter-RAT appended to the RRC state: Shall be possible to perform in the corresponding RRC state on an inter-RAT cell.

5.1.1 SS reference signal received power (SS-RSRP)

Definition	SS reference signal received power (SS-RSRP) is defined as the linear average over the power contributions (in [W]) of the resource elements that carry secondary synchronization signals. The measurement time resource(s) for SS-RSRP are confined within SS/PBCH Block Measurement Time Configuration (SMTC) window duration. If SS-RSRP is used for L1-RSRP as configured by reporting configurations as defined in TS 38.214 [6], the measurement time resources(s) restriction by SMTC window duration is not applicable. For SS-RSRP determination demodulation reference signals for physical broadcast channel (PBCH) and, if indicated by higher layers, CSI reference signals in addition to secondary synchronization signals may be used. SS-RSRP using demodulation reference signal for PBCH or CSI reference signal shall be measured by linear averaging over the power contributions of the resource elements that carry corresponding reference signals taking into account power scaling for the reference signals as defined in TS 38.213 [5]. If SS-RSRP is not used for L1-RSRP, the additional use of CSI reference signals for SS-RSRP determination is not applicable. SS-RSRP shall be measured only among the reference signals corresponding to SS/PBCH blocks with the same SS/PBCH block index and the same physical-layer cell identity. If SS-RSRP is not used for L1-RSRP and higher-layers indicate certain SS/PBCH blocks for performing SS-RSRP measurements, then SS-RSRP is measured only from the indicated set of SS/PBCH block(s). For frequency range 1, the reference point for the SS-RSRP shall be the antenna connector of the UE. For frequency range 2, SS-RSRP shall be measured based on the combined signal from antenna elements corresponding to a given receiver branch. For frequency range 1 and 2, if receiver diversity is in use by the UE, the reported SS-RSRP value shall not be lower than the corresponding SS-RSRP of any of the individual receiver branches.
Applicable for	If SS-RSRP is used for L1-RSRP, RRC_CONNECTED intra-frequency. Otherwise, RRC_IDLE intra-frequency, RRC_IDLE inter-frequency, RRC_INACTIVE intra-frequency, RRC_INACTIVE inter-frequency, RRC_CONNECTED intra-frequency, RRC_CONNECTED inter-frequency

NOTE 1: The number of resource elements within the measurement period that are used by the UE to determine SS-RSRP is left up to the UE implementation with the limitation that corresponding measurement accuracy requirements have to be fulfilled.

NOTE 2: The power per resource element is determined from the energy received during the useful part of the symbol, excluding the CP.

5.1.2 CSI reference signal received power (CSI-RSRP)

Definition	CSI reference signal received power (CSI-RSRP), is defined as the linear average over the power contributions (in [W]) of the resource elements of the antenna port(s) that carry CSI reference signals configured for RSRP measurements within the considered measurement frequency bandwidth in the configured CSI-RS occasions. For CSI-RSRP determination CSI reference signals transmitted on antenna port 3000 according to TS 38.211 [4] shall be used. If CSI-RSRP is used for L1-RSRP, CSI reference signals transmitted on antenna ports 3000, 3001 can be used for CSI-RSRP determination. For intra-frequency CSI-RSRP measurements, if the measurement gap is not configured, UE is not expected to measure the CSI-RS resource(s) outside of the active downlink bandwidth part. For frequency range 1, the reference point for the CSI-RSRP shall be the antenna connector of the UE. For frequency range 2, CSI-RSRP shall be measured based on the combined signal from antenna elements corresponding to a given receiver branch. For frequency range 1 and 2, if receiver diversity is in use by the UE, the reported CSI-RSRP value shall not be lower than the corresponding CSI-RSRP of any of the individual receiver branches.
Applicable for	If CSI-RSRP is used for L1-RSRP, RRC_CONNECTED intra-frequency. Otherwise, RRC_CONNECTED intra-frequency, RRC_CONNECTED inter-frequency

NOTE 1: The number of resource elements within the considered measurement frequency bandwidth and within the measurement period that are used by the UE to determine CSI-RSRP is left up to the UE implementation with the limitation that corresponding measurement accuracy requirements have to be fulfilled.

NOTE 2: The power per resource element is determined from the energy received during the useful part of the symbol, excluding the CP.

5.1.3 SS reference signal received quality (SS-RSRQ)

Definition	Secondary synchronization signal reference signal received quality (SS-RSRQ) is defined as the ratio of N×SS-RSRP / NR carrier RSSI, where N is the number of resource blocks in the NR carrier RSSI measurement bandwidth. The measurements in the numerator and denominator shall be made over the same set of resource blocks. NR carrier Received Signal Strength Indicator (NR carrier RSSI), comprises the linear average of the total received power (in [W]) observed only in certain OFDM symbols of measurement time resource(s), in the measurement bandwidth, over N number of resource blocks from all sources, including co-channel serving and non-serving cells, adjacent channel interference, thermal noise etc. For cell selection, according to Clause 4.1 of TS 38.211 [12], the measurement time resources(s) for NR Carrier RSSI are not constrained. Otherwise, the measurement time resource(s) for NR Carrier RSSI are confined within SS/PBCH Block Measurement Time Configuration (SMTC) window duration. If indicated by higher-layers, if measurement gap is not used, the NR Carrier RSSI is measured in slots within the SMTC window duration that are indicated by the higher layer parameter *measurementSlots* and in OFDM symbols given by Table 5.1.3-1 and, if measurement gap is used, the NR Carrier RSSI is measured in slots within the SMTC window duration that are indicated by the higher layer parameter *measurementSlots* and in OFDM symbols given by Table 5.1.3-1 that are overlapped with the measurement gap, which is defined in TS38.133 [12]. - For intra-frequency measurements, NR Carrier RSSI is measured with timing reference corresponding to the serving cell in the frequency layer - For inter-frequency measurements, NR Carrier RSSI is measured with timing reference corresponding to any cell in the target frequency layer Otherwise not indicated by higher-layers, if measurement gap is not used, NR Carrier RSSI is measured from OFDM symbols within SMTC window duration and, if measurement gap is used, NR Carrier RSSI is measured from OFDM symbols corresponding to overlapped time span between SMTC window duration and the measurement gap. If higher-layers indicate certain SS/PBCH blocks for performing SS-RSRQ measurements, then SS-RSRP is measured only from the indicated set of SS/PBCH block(s). For frequency range 1, the reference point for the SS-RSRQ shall be the antenna connector of the UE. For frequency range 2, NR Carrier RSSI shall be measured based on the combined signal from antenna elements corresponding to a given receiver branch, where the combining for NR Carrier RSSI shall be the same as the one used for SS-RSRP measurements. For frequency range 1 and 2, if receiver diversity is in use by the UE, the reported SS-RSRQ value shall not be lower than the corresponding SS-RSRQ of any of the individual receiver branches.
Applicable for	RRC_IDLE intra-frequency, RRC_IDLE inter-frequency, RRC_INACTIVE intra-frequency, RRC_INACTIVE inter-frequency, RRC_CONNECTED intra-frequency, RRC_CONNECTED inter-frequency

Table 5.1.3-1: NR Carrier RSSI measurement symbols

OFDM signal indication *endSymbol*	Symbol indexes
0	{0,1}
1	For 480 kHz and 960 kHz {0,1,2,..,11,12}; otherwise {0,1,2,..,10,11}
2	{0,1,2,…, 5}
3	{0,1,2,…, 7}