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Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document contains the description and definition of the measurements done at the UE and network in order to support operation in idle mode and connected mode.

2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

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

[2] 3GPP TS 36.201: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer – General Description ".

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

[4] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding ".

[5] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures ".

[6] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[7] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification ".

[8] 3GPP2 CS.0005-D v1.0 "Upper Layer (Layer 3) Signaling Standard for CDMA2000 Spread Spectrum Systems Release D".

[9] 3GPP2 CS.0024-A v3.0 "cdma2000 High Rate Packet Data Air Interface Specification"

[10] 3GPP TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception ".

[11] 3GPP TS 36.355: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)"

[12] 3GPP TS 36.455: "Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol A (LPPa)"

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:

Ec/No Received energy per chip divided by the power density in the band

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].

1x RTT	CDMA2000 1x Radio Transmission Technology
CPICH	Common Pilot Channel
E-SMLC	Enhanced Serving Mobile Location Centre
E-UTRA	Evolved UTRA
E-UTRAN	Evolved UTRAN
FDD	Frequency Division Duplex
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile communication
HRPD	CDMA2000 High Rate Packet Data
P-CCPCH	Primary Common Control Physical Channel
RSCP	Received Signal Code Power
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
RSSI	Received Signal Strength Indicator
RSTD	Reference Signal Time Difference
TDD	Time Division Duplex
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network

4 Control of UE/E-UTRAN measurements

In this chapter 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 E-UTRAN. These measurements can be classified in different reported measurement types: intra-frequency, inter-frequency, inter-system, traffic volume, quality and UE internal measurements (see the RRC Protocol [7]).

In the L1 measurement definitions, see chapter 5, the measurements are categorised as measurements in the UE (the messages for these will be described in the MAC Protocol [6] or RRC Protocol [7] or LPP Protocol [11]) or measurements in the E-UTRAN (the messages for these will be described in the Frame Protocol or LPPa Protocol [12]).

To initiate a specific measurement, the E-UTRAN transmits a ‘RRC connection reconfiguration message' to the UE including a measurement ID and type, a command (setup, modify, release), the measurement objects, the measurement quantity, the reporting quantities and the reporting criteria (periodical/event-triggered), see [7] or E-SMLC transmits an ‘LPP Request Location Information message’ to UE, see [11].

When the reporting criteria are fulfilled the UE shall answer with a 'measurement report message' to the E-UTRAN including the measurement ID and the results or an ‘LPP Provide Location Information message’ to the E-SMLC, see [11].

For idle mode, the measurement information elements are broadcast in the System Information.

5 Measurement capabilities for E-UTRA

In this chapter the physical layer measurements reported to higher layers are defined.

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_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 Reference Signal Received Power (RSRP)

Definition	Reference signal received power (RSRP), is defined as the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth. For RSRP determination the cell-specific reference signals R_0 according TS 36.211 [3] shall be used. If the UE can reliably detect that R_1 is available it may use R_1 in addition to R_0 to determine RSRP. The reference point for the RSRP shall be the antenna connector of the UE. If receiver diversity is in use by the UE, the reported value shall not be lower than the corresponding RSRP of any of the individual diversity branches.
Applicable for	RRC_IDLE intra-frequency, RRC_IDLE inter-frequency, RRC_CONNECTED intra-frequency, RRC_CONNECTED inter-frequency

Note1: The number of resource elements within the considered measurement frequency bandwidth and within the measurement period that are used by the UE to determine 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 Void

5.1.3 Reference Signal Received Quality (RSRQ)

Definition	Reference Signal Received Quality (RSRQ) is defined as the ratio *N*×RSRP/(E-UTRA carrier RSSI), where *N* is the number of RB's of the E-UTRA carrier RSSI measurement bandwidth. The measurements in the numerator and denominator shall be made over the same set of resource blocks. E-UTRA Carrier Received Signal Strength Indicator (RSSI), comprises the linear average of the total received power (in [W]) observed only in OFDM symbols containing reference symbols for antenna port 0, in the measurement bandwidth, over *N* number of resource blocks by the UE from all sources, including co-channel serving and non-serving cells, adjacent channel interference, thermal noise etc. If higher-layer signalling indicates certain subframes for performing RSRQ measurements, then RSSI is measured over all OFDM symbols in the indicated subframes. The reference point for the RSRQ shall be the antenna connector of the UE. If receiver diversity is in use by the UE, the reported value shall not be lower than the corresponding RSRQ of any of the individual diversity branches.
Applicable for	RRC_IDLE intra-frequency, RRC_IDLE inter-frequency, RRC_CONNECTED intra-frequency, RRC_CONNECTED inter-frequency

5.1.4 UTRA FDD CPICH RSCP

Definition	Received Signal Code Power, the received power on one code measured on the Primary CPICH. The reference point for the RSCP shall be the antenna connector of the UE. If Tx diversity is applied on the Primary CPICH the received code power from each antenna shall be separately measured and summed together in [W] to a total received code power on the Primary CPICH. If receiver diversity is in use by the UE, the reported value shall not be lower than the corresponding CPICH RSCP of any of the individual receive antenna branches.
Applicable for	RRC_IDLE inter-RAT, RRC_CONNECTED inter-RAT

5.1.5 UTRA FDD carrier RSSI

Definition	The received wide band power, including thermal noise and noise generated in the receiver, within the bandwidth defined by the receiver pulse shaping filter. The reference point for the measurement shall be the antenna connector of the UE. If receiver diversity is in use by the UE, the reported value shall not be lower than the corresponding UTRA carrier RSSI of any of the individual receive antenna branches.
Applicable for	RRC_IDLE inter-RAT, RRC_CONNECTED inter-RAT

5.1.6 UTRA FDD CPICH Ec/No

Definition	The received energy per chip divided by the power density in the band. If receiver diversity is not in use by the UE, the CPICH Ec/No is identical to CPICH RSCP/UTRA Carrier RSSI. Measurement shall be performed on the Primary CPICH. The reference point for the CPICH Ec/No shall be the antenna connector of the UE. If Tx diversity is applied on the Primary CPICH the received energy per chip (Ec) from each antenna shall be separately measured and summed together in [Ws] to a total received chip energy per chip on the Primary CPICH, before calculating the Ec/No. If receiver diversity is in use by the UE, the measured CPICH Ec/No value shall not be lower than the corresponding CPICH $RSCP_i$/UTRA Carrier $RSSI_i$ of receive antenna branch i .
Applicable for	RRC_IDLE inter-RAT, RRC_CONNECTED inter-RAT

5.1.7 GSM carrier RSSI

Definition	Received Signal Strength Indicator, the wide-band received power within the relevant channel bandwidth. Measurement shall be performed on a GSM BCCH carrier. The reference point for the RSSI shall be the antenna connector of the UE.
Applicable for	RRC_IDLE inter-RAT, RRC_CONNECTED inter-RAT

5.1.8 UTRA TDD carrier RSSI

Definition	The received wide band power, including thermal noise and noise generated in the receiver, within the bandwidth defined by the receiver pulse shaping filter, for TDD within a specified timeslot. The reference point for the measurement shall be the antenna connector of the UE.
Applicable for	RRC_IDLE inter-RAT, RRC_CONNECTED inter-RAT

5.1.9 UTRA TDD P-CCPCH RSCP

Definition	Received Signal Code Power, the received power on P-CCPCH of a neighbour UTRA TDD cell. The reference point for the RSCP shall be the antenna connector of the UE.
Applicable for	RRC_IDLE inter-RAT, RRC_CONNECTED inter-RAT

5.1.10 CDMA2000 1x RTT Pilot Strength

Definition	CDMA2000 1x RTT Pilot Strength measurement is defined in section 2.6.6.2.2 of [8]
Applicable for	RRC_IDLE inter-RAT, RRC_CONNECTED inter-RAT

5.1.11 CDMA2000 HRPD Pilot Strength

Definition	CDMA2000 HRPD Pilot Strength Measurement is defined in section 8.7.6.1.2.3 of [9]
Applicable for	RRC_IDLE inter-RAT, RRC_CONNECTED inter-RAT

5.1.12 Reference signal time difference (RSTD)

Definition	The relative timing difference between the neighbour cell j and the reference cell i, defined as $T_{SubframeRxj} - T_{SubframeRxi}$, where: $T_{SubframeRxj}$ is the time when the UE receives the start of one subframe from cell j $T_{SubframeRxi}$ is the time when the UE receives the corresponding start of one subframe from cell i that is closest in time to the subframe received from cell j. The reference point for the observed subframe time difference shall be the antenna connector of the UE.
Applicable for	RRC_CONNECTED intra-frequency RRC_CONNECTED inter-frequency

5.1.13 UE GNSS Timing of Cell Frames for UE positioning

Definition	The timing between cell j and a GNSS-specific reference time for a given GNSS (e.g., GPS/Galileo/Glonass system time). $T_{UE-GNSS}$ is defined as the time of occurrence of a specified E-UTRAN event according to GNSS time for a given GNSS Id. The specified E-UTRAN event is the beginning of a particular frame (identified through its SFN) in the first detected path (in time) of the cell-specific reference signals of the cell j, where cell j is a cell chosen by the UE. The reference point for $T_{UE-GNSSj}$ shall be the antenna connector of the UE.
Applicable for	RRC_CONNECTED intra-frequency

5.1.14 UE GNSS code measurements

Definition	The GNSS code phase (integer and fractional parts) of the spreading code of the i^{th} GNSS satellite signal. The reference point for the GNSS code phase shall be the antenna connector of the UE.
Applicable for	Void (this measurement is not related to E-UTRAN/UTRAN/GSM signals; its applicability is therefore independent of the UE RRC state)

5.1.15 UE Rx – Tx time difference

Definition	The UE Rx – Tx time difference is defined as $T_{UE-RX} - T_{UE-TX}$ Where: T_{UE-RX} is the UE received timing of downlink radio frame #i from the serving cell, defined by the first detected path in time. T_{UE-TX} is the UE transmit timing of uplink radio frame #i. The reference point for the UE Rx – Tx time difference measurement shall be the UE antenna connector.
Applicable for	RRC_CONNECTED intra-frequency

5.2 E-UTRAN measurement abilities

The structure of the table defining a E-UTRAN measurement quantity is shown below.

Column field	Comment
Definition	Contains the definition of the measurement.

The term "antenna connector" used in this sub-clause to define the reference point for the E-UTRAN measurements refers to the "BS antenna connector" test port A and test port B as described in [10]. The term "antenna connector" refers to Rx or Tx antenna connector as described in the respective measurement definitions.

5.2.1 DL RS TX power

Definition	Downlink reference signal transmit power is determined for a considered cell as the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals which are transmitted by the eNode B within its operating system bandwidth. For DL RS TX power determination the cell-specific reference signals R_0 and if available R_1 according TS 36.211 [3] can be used. The reference point for the DL RS TX power measurement shall be the TX antenna connector.

5.2.2 Received Interference Power

Definition	The uplink received interference power, including thermal noise, within one physical resource block's bandwidth of $N_{\mathrm{sc}}^{\mathrm{RB}}$ resource elements as defined in TS 36.211 [3]. The reported value shall contain a set of Received Interference Powers of physical resource blocks $n_{\mathrm{PRB}} = 0,..., N_{RB}^{UL} - 1$ as defined in TS 36.211 [3]. The reference point for the measurement shall be the RX antenna connector. In case of receiver diversity, the reported value shall be linear average of the power in the diversity branches.

5.2.3 Thermal noise power

Definition	The uplink thermal noise power within the UL system bandwidth consisting of N_{RB}^{UL} resource blocks as defined in [3]. It is defined as (N_o x W), where N_o denotes the white noise power spectral density on the uplink carrier frequency and $W = N_{RB}^{UL} \cdot N_{sc}^{RB} \cdot \Delta f$ denotes the UL system bandwidth. The measurement is optionally reported together with the Received Interference Power measurement, it shall be determined over the same time period as the Received Interference Power measurement, The reference point for the measurement shall be the RX antenna connector. In case of receiver diversity, the reported value shall be linear average of the power in the diversity branches.

5.2.4 Timing advance (T_{ADV})

Definition	Type1: Timing advance (T_{ADV}) type 1 is defined as the time difference T_{ADV} = (eNB Rx – Tx time difference) + (UE Rx – Tx time difference), where the eNB Rx – Tx time difference corresponds to the same UE that reports the UE Rx – Tx time difference. Type2: Timing advance (T_{ADV}) type 2 is defined as the time difference T_{ADV} = (eNB Rx – Tx time difference), where the eNB Rx – Tx time difference corresponds to a received uplink radio frame containing PRACH from the respective UE.

5.2.5 eNB Rx – Tx time difference

Definition	The eNB Rx – Tx time difference is defined as $T_{eNB-RX} - T_{eNB-TX}$ Where: T_{eNB-RX} is the eNB received timing of uplink radio frame #i, defined by the first detected path in time. The reference point for T_{eNB-RX} shall be the Rx antenna connector. T_{eNB-TX} is the eNB transmit timing of downlink radio frame #i. The reference point for T_{eNB-TX} shall be the Tx antenna connector.

5.2.6 E-UTRAN GNSS Timing of Cell Frames for UE positioning

Definition	$T_{E-UTRAN-GNSS}$ is defined as the time of the occurrence of a specified LTE event according to a GNSS-specific reference time for a given GNSS (e.g., GPS/Galileo/Glonass system time). The specified LTE event is the beginning of the transmission of a particular frame (identified through its SFN) in the cell. The reference point for $T_{E-UTRAN-GNSS}$ shall be the Tx antenna connector.

5.2.7 Angle of Arrival (AoA)

Definition	AoA defines the estimated angle of a user with respect to a reference direction. The reference direction for this measurement shall be the geographical North, positive in a counter-clockwise direction. The AoA is determined at the eNB antenna for an UL channel corresponding to this UE.

Annex A (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
02/10/06	-	-	-		Draft version created	-	0.0.0
11/10/06	-	-	-		Minor editorial updates for RAN1#46bis	0.0.0	0.0.1
13/10/06	-	-	-		Endorsed skeleton	0.0.1	0.1.0
27/02/07	-	-	-		Update after 3GPP TSG RAN WG1 #48	0.1.0	0.1.1
05/03/07	-	-	-		RAN1 endorsed version	0.1.1	0.2.0
03/05/07	-	-	-		Update after 3GPP TSG RAN WG1#48bis	0.2.0	0.2.1
08/03/07	-	-	-		RAN WG1#49 endorsed version	0.2.1	0.3.0
31/05/07	RAN#36	RP-070490	-		Presented for information at RAN#36	0.3.0	1.0.0
21/06/07	-	-	-		Update after 3GPP TSG RAN #36	1.0.0	1.0.1
25/06/07	-	-	-		3GPP TSG RAN WG1#49bis endorsed version	1.0.1	1.1.0
17/08/07	-	-	-		Update after 3GPP TSG RAN WG1#48bis	1.1.0	1.1.1
20/08/07	-	-	-		3GPP TSG RAN WG1#50 endorsed version	1.1.1	1.2.0
10/09/07	RAN#37	RP-070732	-		For approval at RAN#37	1.2.0	2.0.0
12/09/07	RAN_37	RP-070732	-	-	Approved version	2.0.0	8.0.0
28/11/07	RAN_38	RP-070949	0001	1	RRC state correction for LTE UE measurements	8.0.0	8.1.0
05/03/08	RAN_39	RP-080145	0003	1	Inclusion of agreements from RAN1#51bis and RAN1#52	8.1.0	8.2.0
28/05/08	RAN_40	RP-080435	0004	-	Introduction of eNode B Measurement of Received Interference Power	8.2.0	8.3.0
28/05/08	RAN_40	RP-080435	0005	-	Introduction of eNode B Measurement of Thermal Noise Power	8.2.0	8.3.0
09/09/08	RAN_41	RP-080671	0006	-	Modification to the RSRP definition	8.3.0	8.4.0
09/09/08	RAN_41	RP-080671	0007	-	Modification of RSRQ definition and removal of RSSI	8.3.0	8.4.0
03/12/08	RAN_42	RP-080985	0008	-	RSRQ Measurement Definition	8.4.0	8.5.0
04/03/09	RAN_43	RP-090237	0009	-	RSRP and RSRQ Definitions with Receiver Diversity	8.5.0	8.6.0
15/09/09	RAN_45	RP-090888	0010		Clarification on reference point of RSRP and RSRQ for EUTRA	8.6.0	8.7.0
01/12/09	RAN_46	RP-091172	0011	1	Introduction of LTE positioning	8.7.0	9.0.0
16/03/10	RAN_47	RP-100205	0012	1	Modification of RSRQ definition	9.0.0	9.1.0
01/06/10	RAN_48	RP-100590	0014	-	On alignment of RAN1/2 positioning specification	9.1.0	9.2.0
01/06/10	RAN_48	RP-100590	0015	1	Clarification of RSTD measurement	9.1.0	9.2.0
07/12/10	RAN_50	-	-	-	Creation of Rel-10 specification	9.2.0	10.0.0
15/03/11	RAN_51	RP-110258	0016	-	RSRQ Measurement with ABS	10.0.0	10.1.0