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Environmental Engineering (EE);
Measurement method for
energy efficiency of wireless access network equipment
Dynamic energy performance measurement method of 5G
Base Station (BS)

Reference

DTS/EE-EEPS39

Keywords

5G, base station, energy efficiency, KPI, NR

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Environmental Engineering (EE).

Modal verbs terminology

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Introduction

Increasing of energy consumption and the related cost has been one of the key questions among the whole industry depending on energy and specially in our context the telecom operators while energy consumption cost is one of the main contributors to their OPEX. Despite the increasing of the OPEX, the environmental aspect in terms of CO2 emission has been one of the most debated subjects within global warming discussions. Energy efficiency is one of the critical factors of the modern telecommunication systems.

In mobile telecom industry the energy consumption of the access network is the dominating part of the wireless telecom network energy consumption. Therefore, the core network and the service network are not considered in the present document. In a radio access network, the energy consumption of the Base Station is dominating.

In context of 5G, one is often talking about three classes of use cases: enhanced Mobile Broadband (eMBB), massive Machine-Type Communication (mMTC) and Ultra-Reliable and Low-Latency Communication (URLLC). eMBB corresponds to a more or less straightforward evolution of the mobile broadband services of today, enabling even larger data volumes and further enhanced user experience, higher end-user data rates while mMTC and URLLC correspond to services characterized by a massive number of devices and services with very low latency and extremely high reliability respectively.

The present document defines the dynamic measurement method for evaluation energy performance of 5G radio base stations with respect to only eMBB use case. Dynamic measurement method for evaluation energy performance of 5G radio base stations with respect to mMTC and URLLC is subjected for further study and will be handled in the later version of the present document. Due to the dynamic nature of eMBB service it may be very difficult or impossible to show gains of some Base Station features that improve energy efficiency using static method alone. Compared to static, dynamic method strives to give more realistic estimates of Base Station's energy consumption.

BS efficiency energy performance under dynamic traffic load conditions: the BS capacity under dynamic traffic load provided within a defined coverage area and the corresponding energy consumption are measured for given reference configurations.

1 Scope

The present document covers the following radio access technology:

- 5G NR

The methodology described in the present document is to measure base station dynamic energy performance. Within the present document, it is referred to dynamic measurement.

The results based on dynamic measurements of the BS provide energy performance information for BS with dynamic loads.

The present document covers only enhanced Mobile Broadband (eMBB) use case of 5G. Other use cases such as massive Machine-Type Communication (mMTC) and Ultra-Reliable and Low-Latency Communication (URLLC) will be subjected for future version of the present document.

Energy consumption of terminal (end-user) equipment is outside the scope of the present document however, how a user equipment (UE) affects a base station energy performance will be considered for further study.

The scope of the present document is not to define target values for the power consumption nor the energy performance of equipment.

The results should only be used to assess and compare the energy performance of complete base stations.

Wide Area Base Stations are covered in the present document.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment; Part 2: -48 V Direct Current (DC)".

[2] ETSI EN 300 132-1: "Environmental Engineering (EE); Power supply interface at the input to Information and Communication Technology (ICT) equipment; Part 1: Alternating Current (AC)".

[3] ETSI EN 300 132-3: "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V".

[4] ETSI TS 138 211: "5G; NR; Physical channels and modulation (3GPP TS 38.211)".

[5] ETSI TS 138 104: "5G; NR; Base Station (BS) radio transmission and reception (3GPP TS 38.104)".

[6] ETSI TS 138 141-1: "5G; NR; Base Station (BS) conformance testing Part 1: Conducted conformance testing (3GPP TS 38.141-1)".

[7] IEC/ISO Guide 98-3 or equivalent GUM:2008/JCGM 100:2008: "Evaluation of measurement data - Guide to the expression of uncertainty in measurement".

NOTE: Available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ISO/IEC 17025: "General requirements for the competence of testing and calibration laboratories".

[i.2] IEC 62018: "Power consumption of information technology equipment - Measurement methods".

NOTE: Equivalent to CENELEC EN 62018.

[i.3] ETSI ES 202 706-1: "Environmental Engineering (EE); Metrics and measurement method for energy efficiency of wireless access network equipment; Part 1: Power Consumption - Static Measurement Method".

[i.4] 3GPP TR 36.873: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Study on 3D channel model for LTE".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

Base Station (BS): radio access network component which serves one or more radio cells and interfaces the user terminal (through air interface) and a wireless network infrastructure

BS test control unit: unit which can be used to control and manage BS locally in a lab

busy hour load: period during which occurs the maximum total load in a given 24-hour period

distributed BS: BS architecture which contains remote radio heads (i.e. RRH) close to antenna element and a central element connecting BS to network infrastructure

efficiency: relation between the useful output (telecom service, etc.) and energy consumption of the BS

integrated BS: BS architecture in which all BS elements are located close to each other; for example, in one single cabinet

NOTE: The integrated BS architecture may include Tower Mount Amplifier (TMA) close to antenna.

low load: lowest generated traffic during the dynamic measurement period

medium load: medium load between the lowest and buy hour load generate during the dynamic measurement period.

power saving feature: software/hardware feature in a BS which contributes to decrease power consumption

static measurement: power consumption measurement performed with different radio resource configurations with pre-defined and fixed load levels (ETSI ES 202 706-1 [i.3])

UE group: group of UEs whose path losses to the BS are identical

Wide Area Base stations: Base Station characterized by requirements derived from Macro Cell scenarios with a BS to UE minimum coupling loss equals to 70 dB and having a rated output power (PRAT) above 38 dBm, where the Rated output power, PRAT, of the BS is the mean power level per carrier for BS operating in single carrier, multi-carrier, or carrier aggregation configurations that the manufacturer has declared to be available at the antenna connector during the transmitter ON period according to 3GPP standardization ETSI TS 138 104 [5] for NR

3.2 Symbols

Void.

3.3 Abbreviations

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

AC	Alternating Current
BS	Base Station
DC	Direct Current
DL	DownLink
DUT	Device Under Test
EC	Energy for Central part
ERRH	Energy for Remote Radio Part
GSM	Global System for Mobile communication
GUM	Guide to the expression of Uncertainty in Measurement
HW	HardWare
JCGM	Joint Committee for Guides in Metrology
KPI	Key Performance Indicator
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
NIST	National Institute of Standards and Technology
NR	New Radio
NSA	Non-StandAlone
OPEX	Operating Expense
PBCH	Packet Broadcast Control Channel
PCM	Pulse Code Modulation
PDF	Probability Density Function
PRB	Physical Resource Block
PSS	Primary Synchronizing Signal
RF	Radio Frequency
RMSI	Remaining Minimum System Information
RRH	Remote Radio Head
RX	Receiver
SA	StandAlone
SDH	Synchronous Digital Hierarchy
SIB	System Information Block
SS	Synchronization Signals
SSB	Synchronization Signal Block
SSS	Secondary Synchronizing Signal
SW	SoftWare
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TMA	Tower Mount Amplifier
TX	Transmitter
UE	User Equipment
UL	UpLink
URLLC	Ultra-Reliable Low-Latency Communication

4 Assessment method

The assessment method is covering the BS equipment dynamic efficiency for which the present document defines reference BS equipment configurations and reference load levels to be used when measuring BS efficiency.

The assessment procedure contains the following tasks:

1) Identification of equipment under test:

   1.1 Identify BS basic parameters (table A.1 in annex A).

   1.2 List BS configuration (annex B).

   1.3 List traffic load(s) for measurements (annex C).

   1.4 List of used power saving features and capacity enhancement features.

2) Efficiency measurement under dynamic load conditions, Measure BS equipment delivered task in terms of bits and the consumed energy under required conditions (see clause 6).

3) Collect and report the efficiency measurement results.

5 Reference configurations and Measurement conditions

5.1 Reference configurations

The BS equipment is a network component which serves a number of user equipment within a specific coverage area over an air interface. A BS interfaces user equipment (through air interface) and a wireless network infrastructure.

Reference configurations are defined annex B.

These configurations include integrated and distributed BS, mast head amplifiers, remote radio heads, RF feeder cables, number of carriers, number of sectors, power range per sector, frequency range, diversity, MIMO.

The BS shall be tested with its intended commercially available configuration at temperatures defined in clause 5.2.5. It shall be clearly reported in the measurement report if the BS cannot be operated without additional air-conditioning at the defined temperatures.

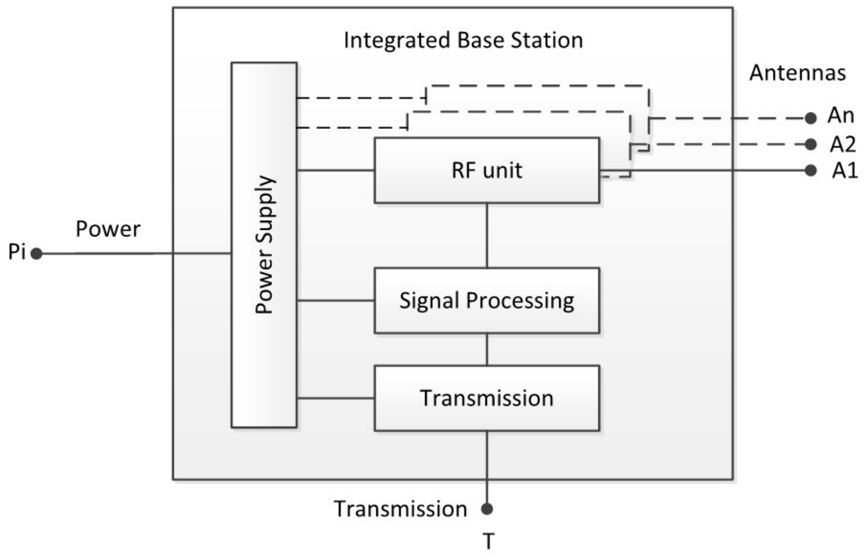

Figure 1: Integrated BS model (Example)

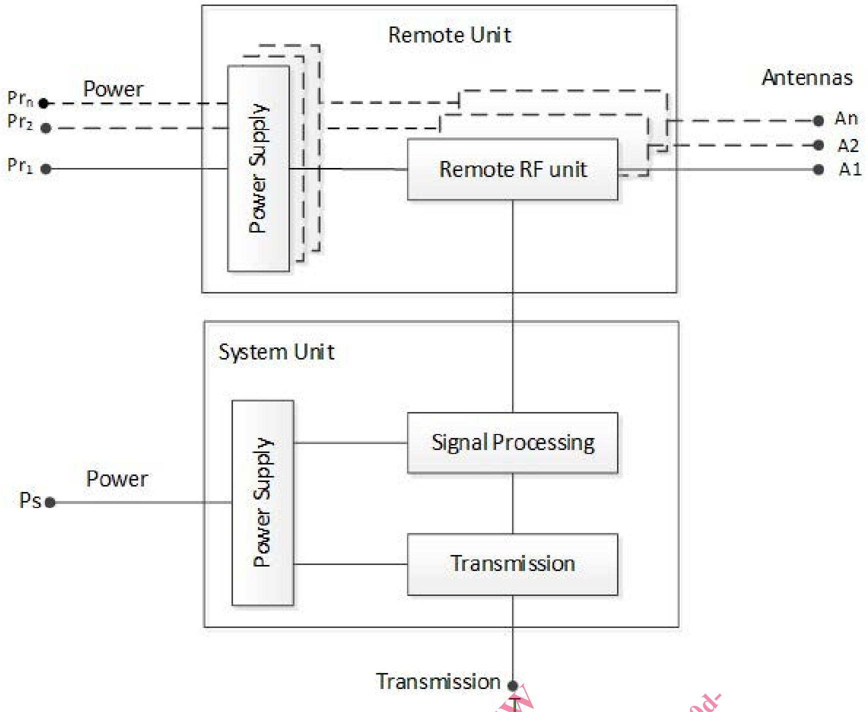

Figure 2: Distributed BS model (Example)

5.2 Measurement and test equipment requirements

5.2.1 Test equipment requirements

The measurement of the power consumption shall be performed by either measuring the power supply voltage and true effective current in parallel and calculate the resulting power consumption (applicable only for DC) or with a wattmeter (applicable for both AC and DC). The measurements can be performed by a variety of measurement equipment, including power clamps, or power supplies with in-built power measurement capability.

All measurement equipment shall be calibrated and shall have data output interface to allow long term data recording and calculation of the complete power consumption over a dedicated time.

The measurement equipment shall comply with following attributes:

- Input power:
  - Resolution: ≤ 10 mA; ≤ 100 mV; ≤ 100 mW.
  - DC current: ±1 %.
  - DC voltage: ±1 %.
  - AC power: ±1 %.
    - An available current crest factor of 5 or more.
    - The test instrument shall have a bandwidth of at least 1 kHz.

NOTE: Additional information on accuracy can be found in IEC 62018 [i.2].

- RF output power accuracy: ±0,4 dB.