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Okoljski inženiring (EE) - Metrika in metoda merjenja energijske učinkovitosti opreme brezžičnega dostopovnega omrežja - 1. del: Poraba energije - Statična merilna metoda

Environmental Engineering (EE) - Metrics and measurement method for energy efficiency of wireless access network equipment - Part 1: Power Consumption - Static Measurement Method

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Foreword

This ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE).

The present document is part 1 of a multi-part deliverable covering the metrics and measurement method for energy efficiency of wireless access network equipment, as identified below:

Part 1: "Power Consumption - Static Measurement Method";

Part 2: "Energy Efficiency - dynamic measurement method".

Modal verbs terminology

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Introduction

Energy efficiency is one of the critical factors of the modern telecommunication systems. 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 the radio access network, the energy consumption of the Base Station is dominating (depending on technology often also referred to as BTS, NodeB, eNodeB, etc. and in the present document denoted as BS). The energy consumption of Radio Network Control nodes (RNC or BSC) are covered in ETSI ES 201 554 [5].

The standard ETSI ES 202 706 defines methods to analyse the power consumption and energy efficiency of base stations in static mode and dynamic mode respectively.

The present document defines the static measurement method for the evaluation of base station power and energy consumption:

- Average power consumption of BS equipment under static test conditions: the BS average power consumption is based on measured BS power consumption data under static condition when the BS is loaded artificially in a lab for three different loads, low, medium and busy hour under given reference configuration.
- Daily average energy consumption.

ETSI ES 202 706-2 [i.8] defines energy efficiency measurement of the base station.

1 Scope

The present document version covers the following radio access technologies:

- GSM.
- WCDMA.
- LTE.
- WiMAX™ (informative only).

The methodology described in the present document is to measure base station static power consumption. Within the present document it is referred to as static measurements.

The results based on "static" measurements of the BS power consumption provide a power and energy consumption figure for BS under static load.

Energy consumption of terminal (end-user) equipment is outside the scope of the present document.

The scope of the present document is not to define target values for the power consumption.

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

Wide Area Base Stations and Medium Range Base Stations are covered in the present document [12].

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] Void.

[2] ETSI TS 125 104: "Universal Mobile Telecommunications System (UMTS); Base Station (BS) radio transmission and reception (FDD) (3GPP TS 25.104)".

[3] CENELEC EN 50160: "Voltage characteristics of electricity supplied by public electricity networks".

[4] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 2: Operated by -48 V direct current (dc)".

[5] ETSI ES 201 554: "Environmental Engineering (EE); Measurement method for Energy efficiency of Mobile Core network and Radio Access Control equipment".

[6] Void.

[7] ETSI TS 125 141 (V8.3.0): "Universal Mobile Telecommunications System (UMTS); Base Station (BS) conformance testing (FDD) (3GPP TS 25.141 version 8.3.0 Release 8)".

[8] ETSI TS 125 101: "Universal Mobile Telecommunications System (UMTS); User Equipment (UE) radio transmission and reception (FDD) (3GPP TS 25.101)".

[9] ETSI TS 136 101: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (3GPP TS 36.101)".

[10] ETSI TS 136 211: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (3GPP TS 36.211)".

[11] ETSI TS 136 141 (V8.6.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) conformance testing (3GPP TS 36.141 version 8.6.0 Release 8)".

[12] ETSI TS 136 104: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (3GPP TS 36.104)".

[13] IEEE 802.16e™: "IEEE Standard for Local and metropolitan area networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands".

NOTE: WiMAX™ Technologies and Standards.

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] Void.

[i.2] IEC/ISO Guide 98-3: "Evaluation of measurement data - Guide to the expression of uncertainty in measurement" 2008 or equivalent GUM:2008/JCGM 100:2008.

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

[i.3] ETSI TS 145 005: "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 45.005)".

[i.4] ISO/IEC 17025: "General requirements for the competence of testing and calibration laboratories".

[i.5] ETSI TS 151 021: "Digital cellular telecommunications system (Phase 2+); Base Station System (BSS) equipment specification; Radio aspects (3GPP TS 51.021)".

[i.6] IEC 62018: "Power consumption of information technology equipment - Measurement methods".

NOTE: Equivalent to CENELEC EN 62018.

[i.7] ETSI TS 102 706 (V1.2.1): "Environmental Engineering (EE); Measurement Method for Energy Efficiency of Wireless Access Network Equipment".

[i.8] ETSI ES 202 706-2: "Environmental Engineering (EE); Metrics and Measurement Method for Energy Efficiency of Wireless Access Network Equipment; Part 2: Energy Efficiency - dynamic measurement method".

[i.9] ETSI TR 103 117: "Environmental Engineering (EE); Principles for Mobile Network level energy efficiency".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions 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: period during which occurs the maximum total load in a given 24-hour period

busy hour load: in static measurement it is the highest measurement level of radio resource configuration and in dynamic measurement is the highest activity level

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

energy consumption: integral of power consumption over time

full load: operating mode including all radio resources and 100 % traffic conditions

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: in static measurement it is the lowest measurement level of radio resource configuration and in dynamic measurement is the lowest activity level

medium load: in static measurement it is the medium measurement level of radio resource configuration and in dynamic measurement is the medium activity level

medium range BS: Base Station that is characterized by a rated output power (PRAT) above 24 dBm and less than or equal to 38 dBm according to ETSI TS 136 104 [12] and ETSI TS 125 104 [2]

multi-band base station: configuration which allows the simultaneous operation on at least two different frequency bands

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

rated output power: rated output power of the base station 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 ETSI TS 136 104 [12] and ETSI TS 125 104 [2]

site correction factor: scaling factor to scale the BS equipment power consumption for reference site configuration taking into account different power supply solutions, different cooling solutions and power supply losses

static measurement: power consumption measurement performed with different radio resource configurations with pre-defined and fixed load levels

wide area BS: Base Station that is characterized by a rated output power (PRAT) greater than 38 dBm according to ETSI TS 136 104 [12] and ETSI TS 125 104 [2]

3.2 Abbreviations

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

AC	Alternating Current
BCCH	Broadcast Control CHannel

BS	Base Station
BSC	Base Station Controller
BTS	Base Transceiver Station
BW	Bandwidth
CA	Carrier Aggregation
CCE	Control Channel Elements
CCH	Common CHannel
CCPCH	Common Control Physical Channel
CP	Cyclic Prefix
CPICH	Common PIlot CHannel
CS	Circuit Switched
DC	Direct Current
DL	DownLink
DPCH	Dedicated Physical CHannel
DUT	Device Under Test
EDGE	Enhanced Datarate GSM Evolution
EPRE	Emitted Power per Resource Element
FCH	Frequency Correction Channel
GERAN	GSM/EDGE Radio Access Network
GP	Guard Period
GSM	Global System for Mobile communication
GUM	Guide to the expression of Uncertainty in Measurement
HSPA	High Speed Packet Access
HW	HardWare
JCGM	Joint Committee for Guides in Metrology
KPI	Key Performance Indicator
LTE	Long Term Evolution
LTE-A	Long Term Evolution advanced
MAP	Media Access Protocol
MCPA	Multi Carrier Power Amplifier
MIMO	Multiple Input Multiple Output
NA	Not Applicable
NIST	National Institute of Standards and Technology
OFDM	Orthogonal Frequency Division Multiplex
PA	Power Amplifier
PBCH	Packet Broadcast Control Channel
PBH	Power during Busy Hour
PC	Power for Central Part
P_{cell}	Primary cell
PCFICH	Physical Control Format Indicator CHannel
PCH	Paging Channel
PCM	Pulse Code Modulation
PDCCH	Physical Downlink Control CHannel
PDF	Proportional Distribution Function
PDSCH	Physical Downlink Shared CHannel
PHICH	Physical Hybrid ARQ Indicator CHannel
PICH	Paging Indicator Channel
PRAT	Rated output power
PRB	Physical Resource Block
PRRH	Power for Remote Radio Head
PSS	Primary Synchronizing Signal
REG	Resource Element Group
RF	Radio Frequency
RMS	Root Mean Square
RNC	Radio Network Controller
RRH	Remote Radio Head
RS	Reference Signals
RX	Receiver
SA	Subframe Assignment
S_{cell}	Secondary cell
SCH	Synchronization Channel
SDH	Synchronous Digital Hierarchy

SIMO	Single Input Multiple Output
SSS	Secondary Synchronizing Signal
SW	SoftWare
TDD	Time Division Duplex
TMA	Tower Mount Amplifier
TRX	Transceiver
TS	Time Slot
TTI	Time Transmit Interval
TX	Transmitter
UE	User Equipment
UL	UpLink
UL/DL	Uplink/Downlink
UTRA	Evolved Universal Terrestrial Radio Access
WCDMA	Wideband Code Division Multiple Access
WiMAX™	Worldwide interoperability for Microwave Access

4 Assessment method

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

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 and traffic load(s) for measurements (annexes D, E, F).
   - 1.3 List of used power saving features and capacity enhancement features.
2) Measure BS equipment power consumption for required load levels (clause 6).
3) Calculate daily energy consumption (clause 7).
4) Collect and report the measurement results.

5 Reference configurations and Measurement conditions

5.0 Introduction

The BS equipment is a network component which serves one or more cells and interfaces the mobile station (through air interface) and a wireless network infrastructure (BSC or RNC) ([i.3] and [2]).

5.1 Reference configurations

Reference configurations are defined for the different technologies (GSM/EDGE, WCDMA/HSPA, LTE, WiMAX™) in the corresponding annexes (annexes D to G).

These configurations include compact 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 5.2.3 "Environmental conditions". It shall be clearly reported in the measurement report if the BS cannot be operated without additional air-conditioning at the defined temperatures.

Appropriate transmission e.g. a transport function for E1/T1/Gbit Ethernet or other providing capacity corresponding to the BS capacity, shall be included in the BS configuration during testing. The configurations include:

1) UL diversity (This is a standard feature in all BS. Therefore it is considered sufficient that the test is performed on the main RX antenna only. The diversity RX shall be active during the measurement without connection to the test signal).

2) DL diversity (Not considered in R99 and HSPA. LTE: Transmission mode 3 "Open loop spatial multiplexing" shall be according to ETSI TS 136 211 [10] (2×2 DL MIMO)).

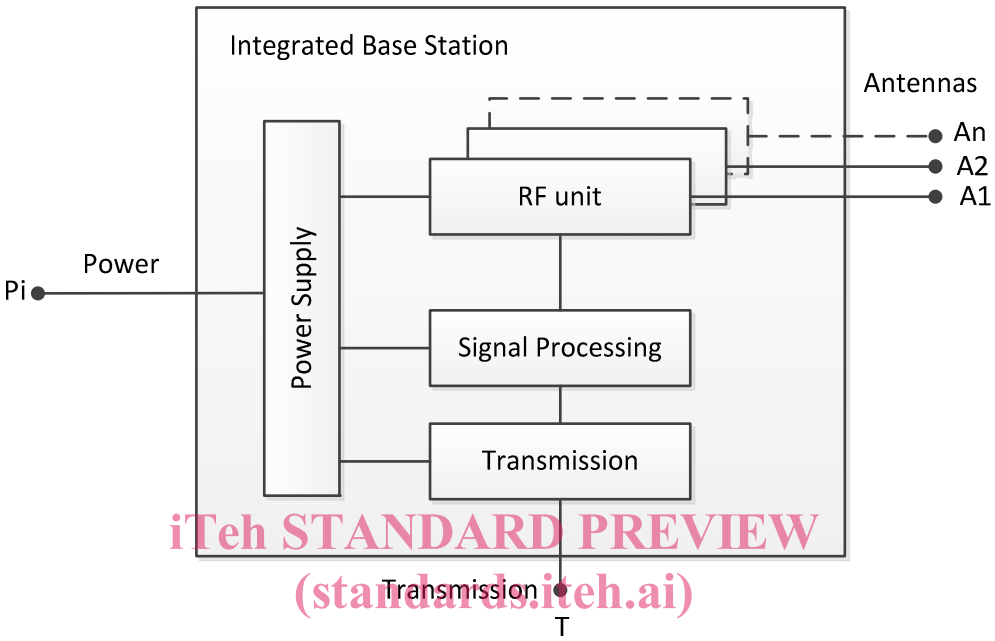

Figure 1: Integrated BS model

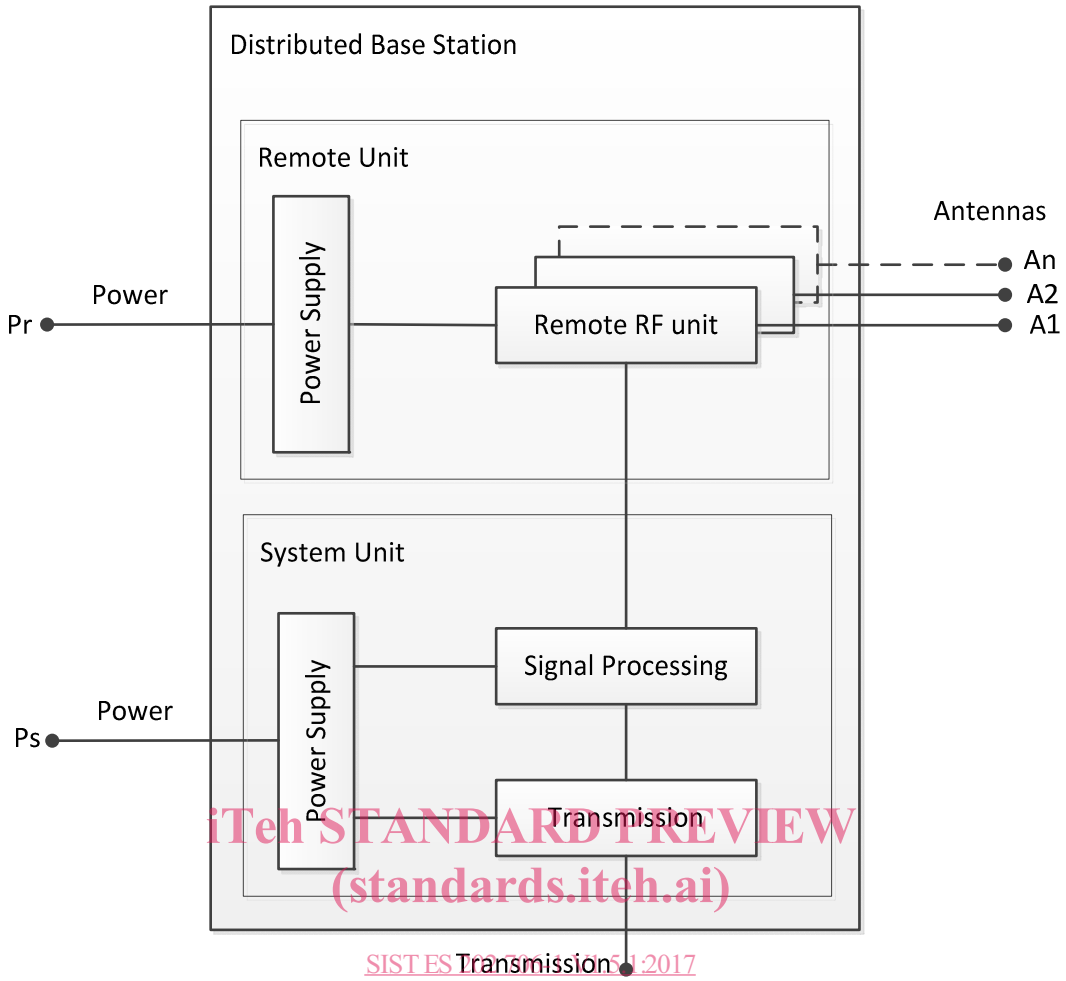

Figure 2: Distributed BS model

5.2 Measurement and test equipment requirements

5.2.0 Introduction

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 in order 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.6].

- RF output power: ±0,4 dB.

5.2.1 BS Configuration

The BS shall be tested under normal test conditions according to the information accompanying the equipment. The BS, test configuration and mode of operation (baseband, control and RF part of the BS as well as the software and firmware) shall represent the normal intended use and shall be recorded in the test report.

The BS shall be tested with its typical configuration. In case of multiple configurations a configuration with 3 sectors shall be used. Examples: a typical wide area BS configuration consists of three sectors and shall therefore be tested in a three sector configuration; another BS configuration might be designed for dual or single sector applications and therefore be tested in the configuration of its intended configuration.

The connection to the simulator via the BS controller interface shall be an electrical or optical cable-based interface (e.g. PCM, SDH, and Ethernet) which is commercially offered along with the applied BS configuration. Additional power consuming features like battery loading shall be switched off.

The power saving features and used SW version shall be listed in the measurement report.

The measurement report shall mention the configuration of the BS for example the type of RF signal combining (antenna network combining, air combining or multi-carrier).

5.2.2 RF output (transmit) power/signal

Due to the different nominal RF output power values of the various BS models and additionally their RF output power tolerances within the tolerance ranges defined by the corresponding mobile radio standards, it is necessary to measure the real RF output power at each RF output connector of the BS.

During the test the BS shall be operated with the nominal RF output powers which would be applied in commercial operation regarding the reference networks and the traffic profiles listed in annexes D, E, F.

The power amplifier(s) of the BS shall support the same crest factor (peak to average ratio) and back-off as applied in the commercial product.

All relevant requirements from the corresponding 3GPP and GERAN specifications for the air-interface, e.g. [2] for WCDMA/HSPA and LTE, shall be fulfilled.

5.2.3 Environmental conditions

For the power consumption measurements the environmental conditions under which the BS has to be tested are defined as follows.

Table 1: BS environmental conditions

Condition	Minimum	Maximum
Barometric pressure	86 kPa (860 mbar)	106 kPa (1 060 mbar)
Relative Humidity	20 %	85 %
Vibration	Negligible	
Temperature	+25 °C and +40 °C	
Temperature accuracy	±2 °C	

The power consumption measurements shall be performed when stable temperature conditions inside the equipment are reached. For this purpose the BS shall be placed in the environmental conditions for minimum two hours with a minimum operation time of one hour before doing measurements.