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ETSI STANDARD

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:

ETSI ES 202 706-1: "Power consumption - static measurement method";

ETSI TS 102 706-2: "Energy Efficiency - dynamic measurement method".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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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, gNodeB, etc. and in the present document denoted as BS).

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

- 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 TS 102 706-2 [i.8] defines energy efficiency measurement of the LTE base station with dynamic load, and ETSI TS 103 786 [i.10] defines energy efficiency measurement of the NR base station with dynamic load.

1 Scope

The present document version covers base stations with the following radio access technologies:

- GSM.

- WCDMA.

- LTE.

- NR.

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

The results based on "static" measurements provide power and energy consumption figures 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 BS power and energy consumption.

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

Wide Area Base Stations and Medium Range Base Stations (as defined in ETSI TS 125 104 [2], ETSI TS 136 104 [12], and ETSI TS 138 104 [15]) 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] Void.

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

[3] 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)".

[4] 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)".

[5] Void.

[6] Void.

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

[8] Void.

[9]   Void.

[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: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) conformance testing (3GPP TS 36.141)".

[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]   Void.

[14]   ETSI EN 300 132-3: "Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment; Part 3: Up to 400 V Direct Current (DC)".

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

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

[17]   ETSI TS 138 141-2: "5G; NR; Base Station (BS) conformance testing Part 2: Radiated conformance testing (3GPP TS 38.141-2)".

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

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

[i.3]   ETSI TS 145 005: "Digital cellular telecommunications system (Phase 2+) (GSM); GSM/EDGE 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+) (GSM); 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 EN 62018 (produced by CENELEC).

[i.7]   Void.

[i.8]   ETSI TS 102 706-2: "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".

[i.10] ETSI TS 103 786: "Environmental Engineering (EE); Measurement method for energy efficiency of wireless access network equipment; Dynamic energy efficiency measurement method of 5G Base Station (BS)".

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

BS type 1-C: NR BS operating at FR1, with a conducted interface (antenna connectors available)

BS type 1-H: NR BS operating at FR1, with both a conducted (TAB connectors) and a radiated interface

BS type 1-O: NR BS operating at FR1, with only a radiated interface (no antenna connectors available)

BS type 2-O: NR BS operating at FR2, with only a radiated interface (no antenna connectors available)

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

busy hour load: the highest measurement level of radio resource configuration

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: lowest measurement level of radio resource configuration

medium load: medium measurement level of radio resource configuration

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

> NOTE 1: According to ETSI TS 136 104 [12], ETSI TS 125 104 [2] and ETSI TS 138 104 [15].

> NOTE 2: For BS type 1-O and BS type 2-O specific definitions apply according to ETSI TS 138 104 [15].

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

radiated interface boundary: reference where the radiated requirements apply for BS type 1-O and 2-O

> NOTE: For requirements based on EIRP, the *radiated interface boundary* is associated to the far-field region.

rated output power: mean power level per carrier that the manufacturer has declared to be available at the antenna connector

NOTE: For FDD BS, rated output power is the mean power level per carrier that the manufacturer has declared to be available at the antenna connector. For TDD BS rated output power is the mean power level per carrier over an active timeslot that the manufacturer has declared to be available at the antenna connector.

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

transceiver array boundary: conducted interface between the transceiver unit array and the composite antenna for BS type 1-H

wide area BS: Base Station that is characterized by a Rated output Power (PRAT) greater than 38 dBm

NOTE 1: According to ETSI TS 136 104 [12], ETSI TS 125 104 [2], and ETSI TS 138 104 [15].

NOTE 2: For BS type 1-O and BS type 2-O specific definitions apply according to ETSI TS 138 104 [15].

3.2 Symbols

Void.

3.3 Abbreviations

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

AAS	Active Antenna System
AAU	Active Antenna Unit
AC	Alternating Current
BCCH	Broadcast Control CHannel
BH	Busy Hour
BS	Base Station
BSC	Base Station Controller
BTS	Base Transceiver Station
CA	Carrier Aggregation
CATR	Compact Antenna Test Range
CCE	Control Channel Element
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
EIRP	Equivalent Isotropically Radiated Power
EPRE	Emitted Power per Resource Element
FDD	Frequency Division Duplex
FL	Full Load
FR1	Frequency Range 1 (450 MHz - 6 000 MHz), defined for NR
FR2	Frequency Range 2 (24 250 MHz - 52 600 MHz), defined for NR
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
LTE	Long Term Evolution
LTE-A	Long Term Evolution Advanced
MCPA	Multi Carrier Power Amplifier
MIMO	Multiple Input Multiple Output
MNO	Mobile Network Operator
MU-MIMO	Multi-User MIMO
NA	Not Applicable
NIST	National Institute of Standards and Technology
NR	New Radio
OFDM	Orthogonal Frequency Division Multiplex
OTA	Over The Air
PBCH	Physical Broadcast Control CHannel
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	Probability Density 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 Synchronization Signal
RE	Resource Element
REG	Resource Element Group
RF	Radio Frequency
RIB	Radiated Interface Boundary
RMSI	Remaining Minimum System Information
RNC	Radio Network Controller
RRH	Remote Radio Head
RS	Reference Signals
RX	Receiver
SA	Subframe Assignment
S_{cell}	Secondary cell
SCH	Synchronization Channel
SCS	Sub-Carrier Spacing
SDH	Synchronous Digital Hierarchy
SF	Spreading Factor
SIB1	System Information Block 1
SIMO	Single Input Multiple Output
SS	Synchronization Signal
SSB	Synchronization Signal Block
SSS	Secondary Synchronization Signal
SW	SoftWare
TAB	Transceiver Array Boundary
TDD	Time Division Duplex
TMA	Tower Mount Amplifier
TRX	Transceiver
TS	Time Slot
TTI	Transmission Time Interval
TX	Transmitter
UE	User Equipment
UL	UpLink
UTRA	Universal Terrestrial Radio Access
WCDMA	Wideband Code Division Multiple 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 RF output power, power consumption and calculating daily average energy consumption.

The assessment procedure contains the following tasks:

1) Identification of equipment under test (clause A.1):

   1.1) Identify BS basic parameters.

   1.2) List BS configuration and traffic load(s) for measurements (annexes B, C, D and E).

   1.3) List used power saving features.

2) Measure BS RF output power and corresponding equipment power consumption for required load levels (clauses 5 and 6).

3) Calculate average power consumption and daily energy consumption (clause 7).

4) Collect and report the measurement and calculation results (clause A.2).

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 (such as BSC or RNC, [i.3] and [2]).

5.1   Reference configurations

Reference configurations are defined for the different technologies (GSM/EDGE, WCDMA/HSPA, LTE, NR) in the corresponding annexes (annexes B to E).

These configurations include integrated BS (Figure 1) and distributed BS (Figure 2), mast head amplifiers, remote radio heads, RF feeder cables, number of carriers, number of sectors, power range per sector, frequency range, diversity, MIMO.

With Active Antenna Systems (AAS), used in NR, more BS types are defined in ETSI TS 138 104 [15]:

- BS type 1-C: NR BS operating at FR1, with a conducted interface (antenna connectors available). This corresponds to legacy integrated BS and distributed BS, illustrated in Figures 1 and 2, respectively.

- BS type 1-H: Distributed NR BS operating at FR1, with both a conducted (at TAB connectors) and a radiated interface at the RIB.

- BS type 1-O and 2-O: Distributed NR BS operating at FR1 or FR2, respectively, with only a radiated interface at the RIB.

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 WCDMA and HSPA. LTE: Transmission mode 3 "Open loop spatial multiplexing" shall be according to ETSI TS 136 211 [10] (2×2 DL MIMO). NR: Rank 1, single layer transmission, (MU-MIMO)).
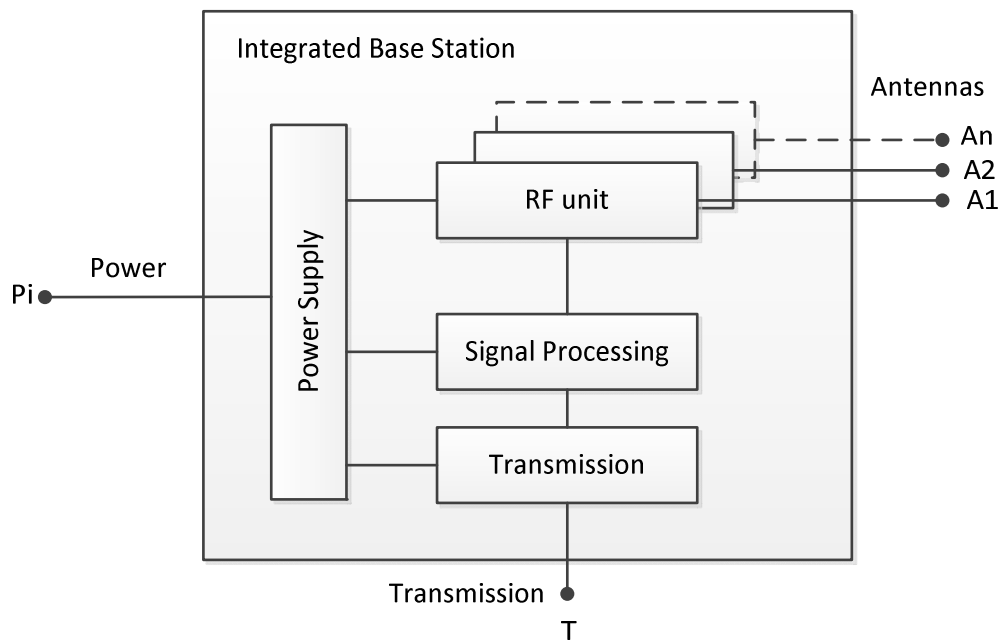
Figure 1: Integrated BS model (example)
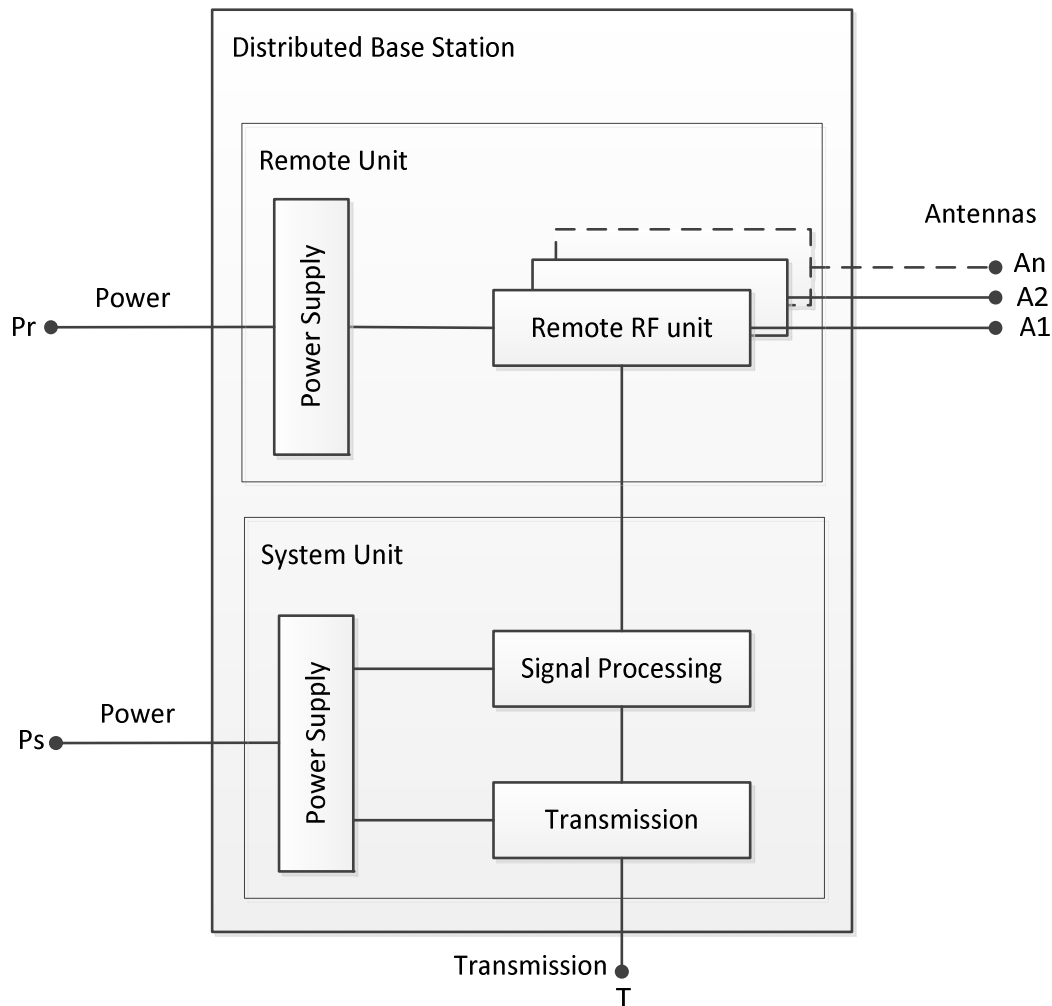
Figure 2: Distributed BS model (example)

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, conducted measurement:

  -   ±0,4 dB.

- RF output power, radiated measurement:

  -   ±1,2 dB (beam peak direction).

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.

EXAMPLE: A typical wide area BS configuration consists of three sectors and shall therefore be tested in a three sector configuration. If a BS is designed for dual or single sector applications, it shall be tested in its designed configuration.

The connection to the BS test control unit 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 (conducted measurement, clause 6.1.1), or Over The Air (OTA) for BS types where RF output connectors are not accessible (radiated measurement, clause 6.1.2).

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 B, C, D and E.

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, LTE [12] and NR [15], shall be fulfilled.

5.2.3   Environmental conditions

The environmental conditions under which the BS has to be tested are defined in Table 1.

The 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 conducting measurements. Also after change of traffic load, a minimum operation time of one hour shall be applied before conducting measurements again.

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	

5.2.4   Power supply

For the measurements, the following operating voltage values shall be used. Equipment designed for non-standard power supply voltages shall use the nominal equipment operating voltage (±2,5 % tolerance).

Nominal values and operating values shall be according to Table 2 and the related ETSI standards.

Table 2: Operating voltages during testing

Supply type	Nominal value	Operating value during testing	Related ETSI standards
AC (230 V)	230 V	230 V (±2,5 %)	ETSI EN 300 132-1 [3]
DC (-48V)	-48 V	-54,5 V (±2,5 %)	ETSI EN 300 132-2 [4]
DC (400 V)	Max. 400 V	380 V (±2,5 %)	ETSI EN 300 132-3 [14]

6   Static Power Measurement

6.0   Introduction

Four load levels are used for the BS power consumption and RF output power test:

- Full Load (FL);

- Busy Hour load (BH);

- medium load (med); and

- low load (low).

They are specified for each radio access technology respectively in annexes B, C, D and E. In case of a distributed BS architecture (e.g. RRH) the power consumption shall be measured for the central baseband unit and remote radio units separately.

NOTE 1: Other load levels are optional and may be measured or interpolated as described in annex I.

NOTE 2: In case of distributed BS with Active Antenna Units (AAU), only comparisons of complete distributed BS should be done, unless same distribution of functionality has been verified.

BS-internal power saving features can be used during testing. In that case, the BS test control unit is allowed to activate and deactivate the features. Used features shall be listed in the measurement report.

6.1   Measurement methods

6.1.0   Introduction

This clause describes the methods to measure the equipment performance taking into account the existing standards as listed in the references in clause 2. It also gives the conditions under which these measurements should be performed in addition to the requirements of clause 5.

The BS shall be operated in a test and measuring environment as illustrated in Figures 3 and 4 for conducted and radiated measurements, respectively.

6.1.1   Test setup for conducted power measurement
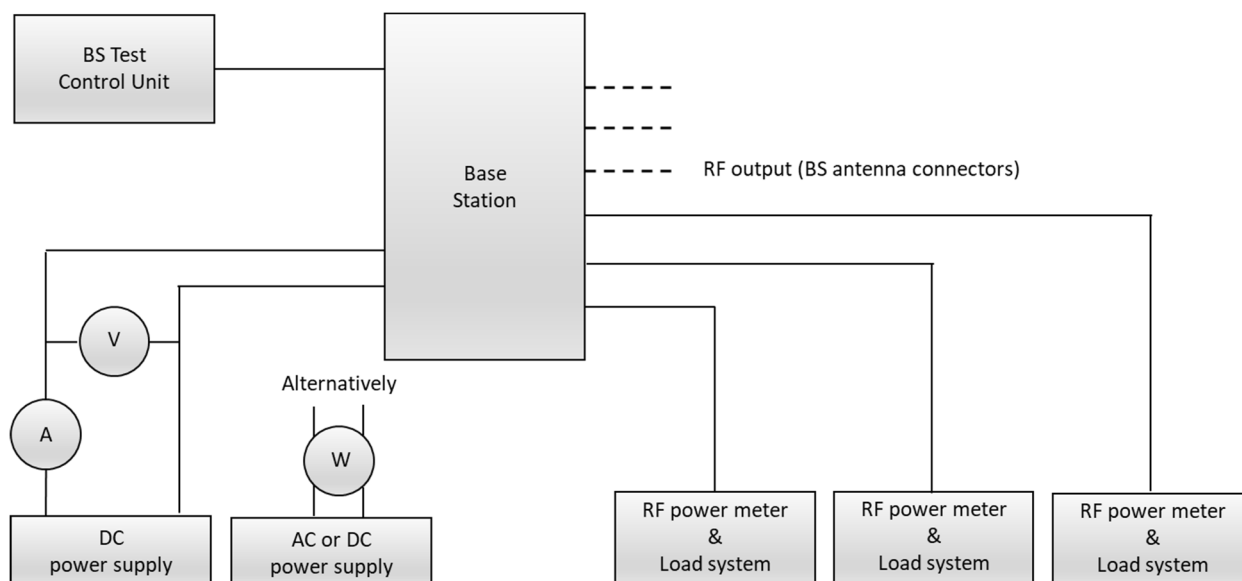
NOTE: BS as defined in Figure 1 (integrated BS) or Figure 2 (distributed BS). AC supply to be used for BS with build in AC power supply, otherwise default DC supply voltage as specified in clause 5.2.

Figure 3: Test set-up for conducted power measurement (example for three sectors)

The BS is powered either by a DC or AC power supply and operated by the BS test control unit. This control unit provides the BS with control signals and traffic data which are required to perform the static measurements. Each RF output (antenna) connector is terminated with a dummy load. The RF output power shall be measured at each antenna connector and reported in the measurement report.

The BS shall be stimulated via the BS controller interface by the emulation of the test-models in conjunction with the traffic profiles and reference parameters given in annexes B, C, D and E.

6.1.2 Test setup for radiated power measurement
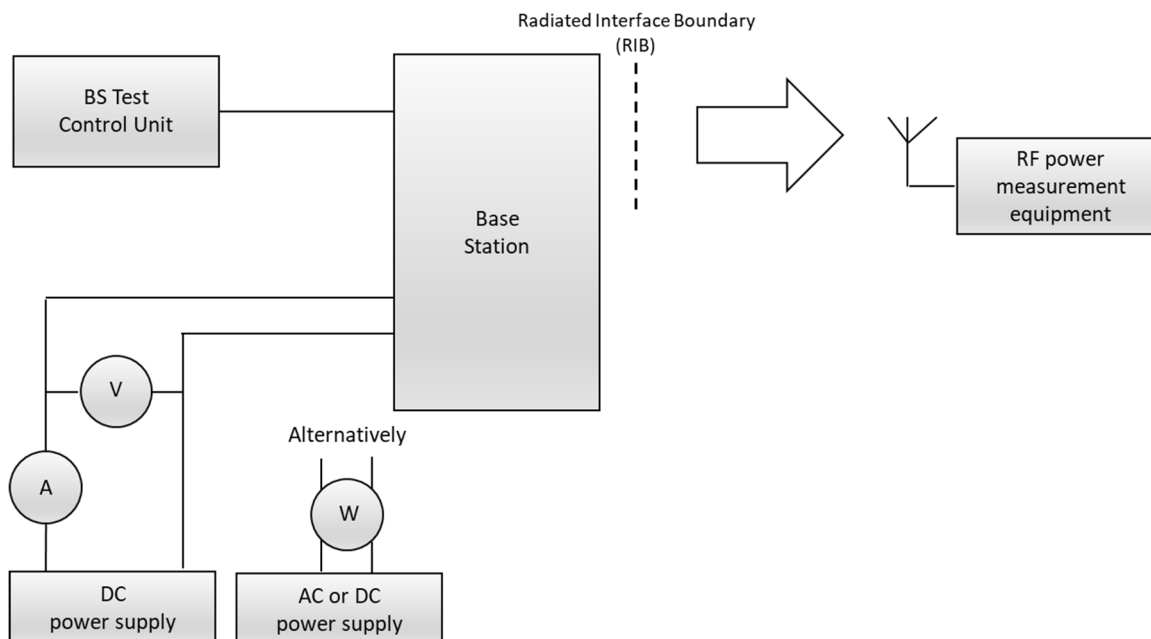
NOTE: BS as defined in Figure 2 (distributed BS). AC supply to be used for BS with build in AC power supply, otherwise default DC supply voltage as specified in clause 5.2.

Figure 4: Test set-up for radiated power measurements (example for one sector)

The BS is powered either by a DC or AC power supply and operated by the BS test control unit. This control unit provides the BS with control signals and traffic data which are required to perform the static measurements.

BS type 1-O and BS type 2-O are declared to support one or more beams, as per manufacturer's declarations specified in ETSI TS 138 141-2 [17]. Radiated transmit power is defined as the EIRP level for a declared beam at a specific beam peak direction.

Each beam is based on declaration of a beam identity, beamwidth, radiated peak directions set, the beam direction at the maximum steering directions and their associated rated beam EIRP and beamwidth.

For a declared beam, the rated beam EIRP level is the maximum power that the base station is declared to radiate at the associated beam peak direction during the transmitter ON period.

For each beam peak direction within the radiated peak directions set, a specific beam EIRP level may be measured.

The following configuration shall be measured:

- Maximum EIRP at beam peak direction.

The EIRP shall be measured over-the-air as specified in ETSI TS 138 141-2 [17], with the BS configured such that the beam peak direction of the declared beam with the highest intended EIRP aligns with the RF power measurement equipment antenna.

The distance between the BS antenna (radiated interface boundary in Figure 4) and the RF power measurement equipment antenna shall be chosen according to instructions for the measurement equipment used (e.g. Far field anechoic chamber, Compact Antenna Test Range (CATR), Near field chamber, etc.) to guarantee a reliable measurement.

The BS shall be stimulated via the BS controller interface by the emulation of the test-models in conjunction with the traffic profiles and reference parameters given in annex E.

6.1.3   Power measurement procedure

The 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 according to clause 5.2.3.

Measurement results shall be captured earliest when the equipment including the selected load is in stable operating conditions. Therefore, also after change of traffic load, a minimum operation time of one hour shall be applied before conducting measurements again. The average value of the DC current and DC voltage should be used for the calculation of the DC power consumption. The RF output powers as well as the corresponding power consumptions of the BS shall be measured with respect to the RF output power levels which are needed to fulfil the requirements from the reference networks as well as the traffic profiles described in annexes B, C, D and E.

The RF output power signal and levels shall be generated according to the test models described in annexes B, C, D and E.

The test models as well as the system depended load levels are defined in annexes B, C, D and E.

For configurations with multiple transmitters operating on the same frequency (MIMO) each transmitter shall transmit the same load as described in the corresponding annex. All RX of the configuration shall be powered on during the measurement.

The reference point for the RF output measurements is for conducted measurement the antenna connector of the BS (or the TAB connector for BS type H), and for radiated measurement the RIB.

The RF output power and corresponding input power consumption shall be measured at the lower, mid and upper edge of the relevant radio band for the low load case. For medium load and busy hour load measurement shall be taken only at middle frequency channel. For the evaluation the single values as well as the arithmetic average of these three measurements (only for low load) shall be stated in the measurement report (Table A.4). The arithmetic average shall be taken for BS reference power consumption evaluation.

The measurement duration of each load level shall be sufficient to acquire a stable and representative result. If the power consumption is fluctuating, the measured power shall be averaged over a sufficiently long time span to achieve a stable and representative result.

   NOTE: The measurement duration is not related to the time duration used in the calculation of average
             power/energy consumption defined in clause 7.

The measurements shall be performed for every antenna which is carrying downlink antenna carrier(s). The measured RF output power values shall be listed in the measurement report for every antenna.

The power consumption of the BS as well as the RF output power shall be given in watts in accordance with the accuracies and the resolutions given in clause 5.2.

The measurement expanded uncertainty shall be assessed according to annex G.

6.1.4   Power measurement in RF sharing mode

Several frequency bands can be used with different cellular network generations. This clause defines power consumption test configurations for simultaneous operation of different cellular standards within one frequency band.

RF sharing combinations depend on the considered frequency band. The following four basic test cases have been defined to demonstrate the RF sharing test method and corresponding results shall be provided for appropriate base stations:

- 900 MHz: GSM 222 + WCDMA 111

- 1 800 MHz: GSM 222 + LTE 111 / 20 MHz (2×2 MIMO)

- 1 800 MHz: LTE 111 / 10 MHz (2×2 MIMO) + NR 111 / 10 MHz (2×2 MIMO)

- 2 100 MHz: WCDMA 111 + LTE 111 / 20 MHz (2×2 MIMO)

The test cases are combinations of test cases specified for GSM, WCDMA, LTE or NR according to annexes B, C, D and E. The reference parameters for above test cases are given in annex F.

NOTE: Similar test cases can be applied to other frequency bands and configurations according to the capability of the BS under test.

6.1.5 Power measurement of multi-band configurations

6.1.5.0 Introduction

This clause outlines multi-band power consumption test configurations. A multi-band base station is a configuration which allows simultaneous operation on at least two different frequency bands and the different bands are managed jointly (for example a GSM 900/1 800 multiband BS with one BCCH to manage both bands simultaneously). A multi-band configuration can be created for different applications:

1) The same technology is used on two independent frequency bands (for example GSM 900 MHz + GSM 1 800 MHz) but with a common control channel.

2) Two different technologies are used on two independent frequency bands (example GSM 900 MHz + WCDMA 1 800 MHz).

3) Multi-band carrier aggregation (example LTE-A with LTE 900 MHz + LTE 2 600 MHz CA).

NOTE: In the present document, no NR multi-band configurations have been defined.

6.1.5.1 Configuration of a multi-band BS

Multi-band configurations shall be tested based on combinations of configurations and test models already defined for single band operations.

Where applicable, only one set of common control channels for both bands shall be assigned.

6.1.5.2 Specific configurations for dual band GSM

For dual band GSM, the test configurations defined in annex B shall be used. These test configurations consider BCCH on the band where the configuration provides the largest coverage (usually the lower band).

6.1.5.3 Specific configurations for dual band LTE (LTE-A)

One differentiator between LTE and LTE-A is the introduction of carrier aggregation. This multi-band specification shall be applied to LTE-A base stations able to operate simultaneously on different bands according to ETSI TS 136 104 [12], Table 5.5-3 inter-band carrier aggregation bands (two bands) and Table 5.5-4 inter-band carrier aggregation bands (three bands).

Traffic load (number of PRBs), PCFICH, reference and synchronization signals shall be transmitted in each band as specified in annex D for single band LTE.

Principal configuration:

- 2×2 MIMO per cell.

- Carrier aggregation with two cells in different bands (primary and secondary cell).

- 10 MHz carrier bandwidth per band shall be tested, 20 MHz per band optional.

- RF power per antenna per sector and per cell: see clause 5.2.2 and annex D.

Test result reporting:

- Detailed report of configuration, power consumption and RF output power for each measured configuration, including description of tested configuration.

- Report of power consumption and RF output power, for all measured elements and load levels, to allow the Mobile Network Operator (MNO) to utilize test results for detailed network analysis.

- Calculation of average power consumption and daily energy consumption as specified in clause 7.

NOTE 1: Comparison of power consumption is only sensible for the same operating frequency band combination for Pcell and Scell, the same power levels and bandwidth per carrier and same load levels.

NOTE 2: CA with independent BS at different locations is not considered here. Also in-band CA, which is possible for MNOs with wider spectrum (e.g.: 40 MHz spectrum CA with 20 + 20 MHz) is not considered.

NOTE 3: The total throughput in CA depends on the capability of the UE (ability to connect to multiple BS simultaneously to increase max. user data rate). A combined base station/UE test setup is essentially limited by the UE capabilities. Therefore, only a static power consumption test is considered for multi-band LTE-A BS.

6.1.5.4 Specific configurations for dual band and dual technology

Multi-band multi-technology (examples: GSM + WCDMA, GSM + LTE, etc.) shall be created based on the load models for each respective technology (annexes B, C, D) and the requirements described in clause 6.1.4 for multi-technology base stations.

6.2 Uncertainty

The measurement expanded uncertainty shall be assessed according to annex G.

7 Calculation results

7.1 Load distribution profile

For the calculation of the weighted average power/energy consumption, weighting factors based on a daily (24 hours) traffic load distribution profile consisting of three of the four measured load levels; low load (low), medium load (med), and Busy Hour (BH) load are used. The load distribution profile consists of duration in hours of the different load levels, t_{low}, t_{med} and t_{BH}. An MNO is allowed to define a load distribution profile reflecting the situation in the network and mandate that profile to be used. Note that the selected load durations shall sum up to 24 hours. In case no load distribution profile has been defined, the default values in Table 3 can be used.

Table 3: Load level durations for daily average calculation

	Low load	Medium load	Busy hour load
Duration/day	t_{low}	t_{med}	t_{BH}
Default value	6 hours	10 hours	8 hours

7.2 Integrated base station

7.2.0 Introduction

The power consumption of integrated BS equipment is measured at the three different load levels of the load distribution profile in clause 7.1:

- P_{BH} is the power consumption [W] with busy hour load.

- P_{med} is the power consumption [W] with medium load.

- P_{low} is the power consumption [W] with low load.

The load levels are implemented differently for each radio access technology. The details of the different load levels are provided in annexes B (GSM), C (WCDMA), D (LTE) and E (NR).

7.2.1 Calculation of average power consumption of integrated BS

The average power consumption [W] of integrated BS equipment in static method is defined as:

$$P_{equipement,static} = \frac{P_{BH} \cdot t_{BH} + P_{med} \cdot t_{med} + P_{low} \cdot t_{low}}{t_{BH} + t_{med} + t_{low}}$$

(7.1)

The values should include all sectors of the configuration at test.

7.2.2 Calculation of daily energy consumption of integrated BS

The daily energy consumption [Wh] of integrated BS equipment in static method is defined as:

$$E_{equipement,static} = P_{BH} \cdot t_{BH} + P_{med} \cdot t_{med} + P_{low} \cdot t_{low}$$

(7.2)

The values should include all sectors of the configuration at test.

7.3 Distributed base station

7.3.0 Introduction

The power consumption of distributed BS equipment is measured for the three load levels in clause 7.1, with separate measurements for the BBU/central (P_C) unit and remote units. (P_{RRH}):

- $P_{BH,C}$ and $P_{BH,RRH}$ are the power consumption [W] of central and remote parts of BS with busy hour load.

- $P_{med,C}$ and $P_{med,RRH}$ are the power consumption [W] of central and remote parts of BS with medium load.

- $P_{low,C}$ and $P_{low,RRH}$ are the power consumption [W] of central and remote parts of BS with low load.

The load levels are implemented differently for each radio access technology. The details of the different load levels are provided in annexes B (GSM), C (WCDMA), D (LTE) and E (NR).

7.3.1 Calculation of average power consumption of distributed BS

The average power consumption [W] of distributed BS equipment is defined as:

$$P_{equipement,static} = P_{c,static} + P_{RRH,static},$$

(7.3)

in which $P_{C, static}$ and $P_{RRH, static}$ [W] are average power consumption of central and remote parts in static method defined as:

$$P_{c,static} = \frac{P_{BH,C} \cdot t_{BH} + P_{med,C} \cdot t_{med} + P_{low,C} \cdot t_{low}}{t_{BH} + t_{med} + t_{low}}$$

(7.4)

$$P_{RRH,static} = \frac{P_{BH,RRH} \cdot t_{BH} + P_{med,RRH} \cdot t_{med} + P_{low,RRH} \cdot t_{low}}{t_{BH} + t_{med} + t_{low}}$$

(7.5)

The values should include all sectors of the configuration at test.

This average power consumption of distributed BS equipment does not include the DC feeder loss for remote parts.

7.3.2   Calculation of daily energy consumption of distributed BS

The daily energy consumption [Wh] of central and remote parts in static method defined as:

$$E_{C,static} = P_{BH,C} \cdot t_{BH} + P_{med,C} \cdot t_{med} + P_{low,C} \cdot t_{low} \qquad (7.6)$$

$$E_{RRH,static} = P_{BH,RRH} \cdot t_{BH} + P_{med,RRH} \cdot t_{med} + P_{low,RRH} \cdot t_{low} \qquad (7.7)$$

The daily energy consumption [Wh] of distributed BS equipment in static method is defined as:

$$E_{equipement,static} = E_{c,static} + E_{RRH,static}, \qquad (7.8)$$

The values should include all sectors of the configuration at test.

This daily energy consumption of distributed BS equipment does not include the DC feeder loss for remote parts.

8   Measurement report

The results of the assessments shall be reported accurately, clearly, unambiguously and objectively, and in accordance with any specific instructions in the required method(s).

A list of reference parameters, load distribution profile, measurement conditions, test results, uncertainty analysis (see annex G) and derived calculation results which shall be reported is given in annex A.

Further guidelines on the test report can be found in ISO/IEC 17025 [i.4].

Annex A (normative):
Test Reports

A.1   General information to be reported

Table A.1: Test general information

Items	Remarks
1) Test report reference and version	
2) Date of the test	
3) Standard Used as test methodology	
4) Location of the test	
5) Name of test organization and responsible person	
6) Tested equipment	
6.1) Tested HW unit names and serial numbers	
6.2) Software version of tested equipment	
7) List of used measurements equipment including type, serial number and calibration information	

Table A.2: BS reference parameters to be reported

Parameter	Value	Unit
1) BS configuration		
1.1) Number of sectors		
1.2) Nominal max RF output power per sector		W
1.3) Number of Carriers per sector		
1.3.1) Number of carriers the BS is able to support		
1.3.2) Number of carriers, for which the HW was enabled (independent whether or not the carriers were used for the test)		
1.3.3) Number of carriers used during the test		
1.4) TX diversity		
1.5) RX diversity,(number)		
1.6) Type of RF signal combining		
1.7) Remote Radio Head (Yes/No)		
1.8) Number of SS blocks per SSB set (only for NR)		
2) Frequency		
2.1) Downlink band		MHz
2.2) Uplink band		MHz
2.3) Channel bandwidth		MHz
2.4) Sub-carrier spacing (only for NR)		kHz
3) Environment		
3.1) Temperature range		°C
3.2) Type of air filter		
4) Features		
4.1) Power saving features		
4.2) Coverage and capacity features		
4.3) Downlink ciphering used? (Y/N)		

Table A.3: Daily load distribution profile to be reported

Load level duration (see note)	Value	Unit
1) Low load duration/day (t_{low})		h
2) Medium load duration/day (t_{med})		h
3) Busy hour duration/day (t_{BH})		h
NOTE: Selected values shall sum to 24 h.		

A.2   Static measurement report

Table A.4: Measurements conditions and results to be reported

Parameter	Test case 25 °C	Test case 40 °C	Unit
1) Test environment			
1.1) Temperature during test (measured)			°C
1.2) Pressure (measured)			kPa
1.3) Relative humidity (measured)			%
2) Frequency used at test			
2.1) downlink Centre frequency of low end channel			MHz
2.2) downlink Centre frequency of middle channel			MHz
2.3) downlink Centre frequency of high end channel			MHz
2.4) Uplink Centre frequency of middle channel			MHz
3) Supply voltage			
3.1) DC voltage (measured)			V
3.2) AC voltage (measured, phase to neutral)			V
3.3) AC frequency (measured)			Hz
4) Static power consumption (measured)			
4.1) Full load, Middle frequency channel			W
4.2) Busy hour load, Middle frequency channel			W
4.3) Medium load, Middle frequency channel			W
4.4) Low load			W
4.4.1) Low end frequency channel			W
4.4.2) Middle frequency channel			W
4.4.3) High end frequency channel			W
4.4.4) Average consumption with low load			W
5) RF output power			
5.1) Full load, Middle frequency channel			W
5.2) Busy hour load, Middle frequency channel			W
5.3) Medium load, Middle frequency channel			W
5.4) Low load			W
5.4.1) RF output power at low end channel			W
5.4.2) RF output power at middle end channel			W
5.4.3) RF output power at high end channel			W
5.4.4) Average RF output power with low load			W
6) RX receiver sensitivity at middle channel			dBm
7) Expanded uncertainty			%

The measurement report shall include the uncertainty table following the template defined in Table G.1.

Table A.5: Average power consumption reporting

Parameter	Value	Unit
1) $P_{equipment}$ of integrated BS power consumption at 25 °C		W
2) $P_{equipment}$ of integrated BS power consumption at 40 °C		W
3) $P_{equipment}$ of distributed BS power consumption at 25 °C		W
3.1) $P_{equipment}$ of distributed BS power consumption at 25 °C for central part		W
3.2) $P_{equipment}$ of distributed BS power consumption at 25 °C for remote parts		W
4) $P_{equipment}$ of distributed BS power consumption at 40 °C		W
4.1) $P_{equipment}$ of distributed BS power consumption at 40 °C for central part		W
4.2) $P_{equipment}$ of distributed BS power consumption at 40 °C for remote parts		W

Table A.6: Daily energy consumption reporting

Parameter	Value	Unit
1) $E_{equipment}$ of integrated BS energy consumption at 25 °C		Wh
2) $E_{equipment}$ of integrated BS energy consumption at 40 °C		Wh
3) $E_{equipment}$ of distributed BS energy consumption at 25 °C		Wh
3.1) $E_{equipment}$ of distributed BS energy consumption at 25 °C for central part		Wh
3.2) $E_{equipment}$ of distributed BS energy consumption at 25 °C for remote parts		Wh
4) $E_{equipment}$ of distributed BS energy consumption at 40 °C		Wh
4.1) $E_{equipment}$ of distributed BS energy consumption at 40 °C for central part		Wh
4.2) $E_{equipment}$ of distributed BS energy consumption at 40 °C for remote parts		Wh

The measurement report shall include the uncertainty table following the template defined in Table G.1.

Annex B (normative):
Reference parameters for GSM/EDGE system

Reference configurations for GSM/EDGE:

- Number of sectors and carriers: 222 (2 carriers per sector, 3 sectors), 444, 888.

- Power Input: -48 V DC, +24 V DC, 230 V AC, 400 V DC.

- Nominal TX power to be used for TS with user traffic.

- RF output power level: Applicable range from 3 W to 100 W.

GSM load model:

The test model is derived from measurements used in clause 6.5.2 of ETSI TS 151 021 [i.5] and defines the RF output composition as shown in Table B.1 and Figure B.1.

For Multi Carrier Power Amplifier (MCPA) the carrier spacing shall be equidistant over the specified bandwidth. The used carrier spacing and total bandwidth shall be stated in measurement report.

Load allocation rules for:

- Full load: all time slots are active.

- Busy hour load: the active time slots are equally distributed over all TRX required for the relevant test case (222, 444, 888).

- Medium and low load: the number of active TRX can be optimized with the help of power saving features available in the BS.

Table B.1: Load model for GSM

	Low load	Medium load	Busy hour load
222 single band	BCCH: Figure B.1 Other TRX: Idle	BCCH: Figure B.1 Other TRX: idle.	BCCH: Figure B.1 (TRX 1) Other TRX: 2 active TS per each sector at static power level. Other TS idle.
444 single band	BCCH: Figure B.1 Other TRX: Idle	BCCH: Figure B.1 Other TRX 6 active TS per each sector at static power level. Other TS idle.	BCCH: Figure B.1 (TRX 1) Other TRX: 12 active TS per each sector at static power level. Other TS idle.
444 dual band	**1st layer:** BCCH: Figure B.1 **2nd layer:** TRX: Idle	**1st layer:** BCCH: Figure B.1 Other TRX 6 active TS per each sector at static power level. Other TS idle **2nd layer:** TRX: Idle. See note.	**1st layer:** BCCH: Figure B.1 (TRX 1) Other TRX: 6 active TS per each sector at static power level. Other TS idle. **2nd layer:** 6 active TS per each sector at static power level. Other TS idle.
888 single band	BCCH: Figure B.1 Other TRX: Idle	BCCH: Figure B.1 Other TRX 18 active TS per each sector at static power level. Other TS idle.	BCCH: Figure B.1 (TRX 1) Other TRX 36 active TS per each sector at static power level. Other TS idle.
888 dual band	**1st layer:** BCCH: Figure B.1 **2nd layer:** TRX: Idle	**1st layer:** BCCH: Figure B.1 Other TRX 18 active TS per each sector at static power level. Other TS idle. **2nd layer:** TRX: Idle. See note.	**1st layer:** BCCH: Figure B.1 (TRX 1) Other TRX: 18 active TS per each sector at static power level. Other TS idle. **2nd layer:** 18 active TS per each sector at static power level. Other TS idle.
NOTE:	The number of active TRX can be optimized with the help of power saving features available in the BS. Idle means that TRX is active but not transmitting.		
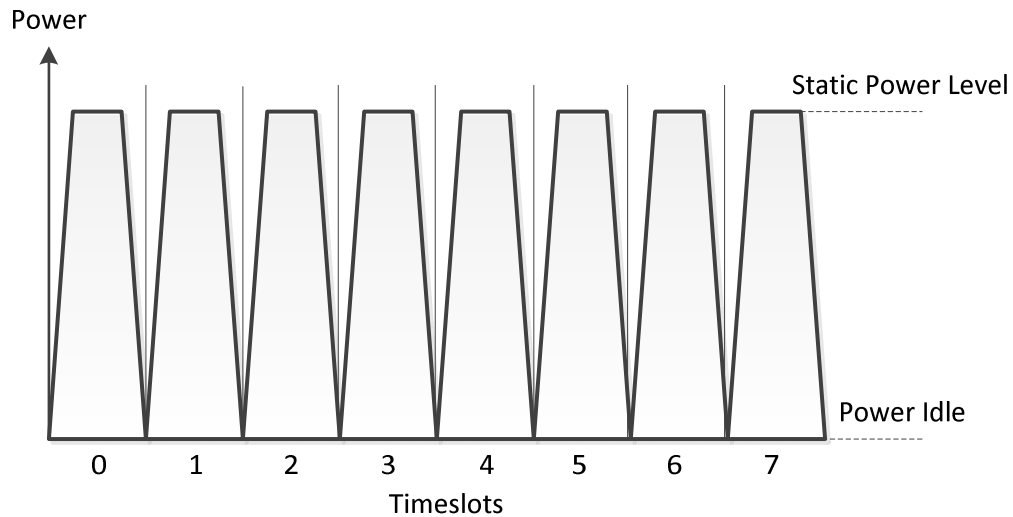
Figure B.1: Power levels for BCCH TRX (all TS active)

Model for GSM subscriber and busy hour traffic:

- CS voice traffic: 0,020 Erlangs/subscriber during Busy Hour.

Table B.2: Busy hour traffic for GSM site

Model for busy hour average traffic load according to Table B.1	Busy hour traffic
S222	18 Erlangs (3×6)
S444	51 Erlangs (3×17)
S888	123 Erlangs (3×41)

Frequency bands for GSM/EDGE:

The frequency band shall be as defined in ETSI TS 145 005 [i.3] and according to equipment specifications. For measurement centre frequency of the specified band is used as a reference unless otherwise specified.

Annex C (normative):
Reference parameters for WCDMA/HSDPA system

Reference configurations for WCDMA/HSDPA shall be:

- Number of sectors and carriers: 111.

- Channel capacity: Able to handle busy hour traffic + extra 50 %.

- RF output power level:

    - Power Range applicable to the "Wide Area BS" and "Medium Range BS" (for static measurements) classes as defined in ETSI TS 125 104 [2].

    - Maximum nominal RF output power at antenna connector according to product specification.

- Power Input: -48 V DC, 230 V AC, 400 V DC.

WCDMA/HSDPA static load model:

The test model shall be according ETSI TS 125 141 [7], clause 6.1.1.1, Test Model 1. For RF output powers below 100 %, only a dedicated number of codes out of 64 (counted from top of the table) shall be used to generate the desired RF-load as stated in Table C.1:

- For a RF load of 50 %, only the first 15 codes listed in Test Model 1 shall be applied (DPCH power: 27,8 %).

- For a RF load of 30 % only the first 3 codes shall be applied (DPCH power: 7,53 %).

- Regarding a RF load of 10 % only the "Primary CPICH" shall be activated. For full load, all Transmit Time Intervals (TTI) and codes shall be transmitting.

The DPCH power given above is relative to the maximum output power on the TX antenna interface under test. CCH contains P-CCPCH+SCH, Primary CPICH, PICH and S-CCPCH (including PCH (SF = 256)).

Table C.1: Load model for WCDMA/HSDPA

	Low load (10 %)	Medium load (30 %)	Busy hour load (50 %)
RF load for 111 per cell	Only Primary CPICH	CCH + first 3 codes	CCH + first 15 codes

Coverage measurement setup configuration:

- WCDMA/HSDPA according to ETSI TS 125 141 [7], clause 6.1.1.4A, Test model "5" (P-CCPCH+SCH, Primary).

- CPICH, PICH, S-CCPCH (containing PCH (SF = 256)).

Frequency bands for WCDMA/HSDPA:

The frequency band shall be as defined in ETSI TS 125 104 [2], Table 5.0 Frequency bands, and according to equipment specifications. For measurement centre frequency of the specified band is used.

Annex D (normative):
Reference parameters for LTE system

Reference configurations for LTE shall be:

- Only normal cyclic prefix is used.

- PBCH shall be transmitted.

- PDCCH REG EPRE and PDSCH PRB P_A shall be used as defined in E-TM1.1 [11].

- Usage of PDSCH PRBs and PSS & SSS & PBCH can overlap for medium load and busy hour load.

- PDCCH CCE allocation can be selected freely for medium load and busy hour load.

- Placement of PDSCH PRBs for medium and busy hour load, can be selected freely within each 10 ms radio frame. For examples, see annex J.

- Number of sectors and transmitters (for FDD):

  - 111 (1 carrier, 1 TX, 2 RX-paths per sector, SIMO);

  - 111 (1 carrier, 2 TX, 2 RX-paths per sector, MIMO);

  - carrier bandwidth: FDD 10 MHz and 20 MHz shall be tested.

- Number of sectors and transmitters (for TDD):

  - 111 (1 carrier, 2 TX, 2 RX-paths per sector, MIMO);

  - 111 (1 carrier, 4 TX, 4 RX-paths per sector, MIMO);

  - 111 (1carrier, 8 TX, 8 RX-paths per sector, MIMO);

  - carrier bandwidth: TDD 20 MHz shall be tested.

- No other physical channels and signals (e-pdcch, prs, csi-rs, ue specific rs, etc.) are transmitted.

- RF output power level:

  - Power Range applicable to the "Wide Area BS" and "Medium Range BS" (for static measurements) classes as defined in ETSI TS 136 104 [12].

  - Maximum nominal RF output power at antenna connector according to product specification and according to the load levels (Output power at antenna connector = load model based percentage $\times$ Maximum nominal RF output power) measured at the antenna connector according to ETSI TS 136 141 [11].

- Power Input:

  - -48 V DC, 230 V AC, 400 V DC.

Downlink and uplink settings for LTE TDD:

The subframe settings SA2 and special subframe settings SSP7 as defined in ETSI TS 136 211 [10] are applied for the power consumption test, see Tables D.1 and D.2.

Table D.1: Uplink-downlink subframe configurations SA 2

Uplink-Downlink Subframe Configuration	Uplink/Downlink Subframe Ratio	Downlink-to-Uplink Switch-Point Period	0	1	2	3	4	5	6	7	8	9
SA2	1:3	5 ms	D	S	U	D	D	D	S	U	D	D
NOTE: D denotes a downlink subframe, U denotes an uplink subframe, and S denotes a special subframe. A special subframe can be used for downlink data transmission, but not for uplink data transmission. Therefore, a special subframe is considered a downlink subframe. For more details about special subframes see ETSI TS 136 211 [10].												

Table D.2: Special subframe configuration SSP7

Special Subframe Configuration	Normal CP				Extended CP (Applicable to Macro eNodeBs Only)			
N/A	DwPTS	GP	UpPTS	Cell Radius (km)	DwPTS	GP	UpPTS	Cell Radius (km)
SSP7	10	2	2	15,41	5	5	2	56,35

LTE static load model:

The test model shall be according ETSI TS 136 141 [11], clause 6.1.1.1, Test Model E-TM1.1, with the following adaptations:

- **For low load:**

  - All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH shall not be transmitted.

- **For medium load:**

  - All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH shall be limited as following:

    - Only a certain number of PRBs dedicated to PDSCH shall be transmitted. The number of transmitted PRBs dedicated to PDSCH shall be calculated as such, for 10 MHz bandwidth 15 PRBs and 20 MHz bandwidth 30 PRBs.

    - As for the PDSCH, the amount of transmitted control channel resources shall be such that the power of the first OFDM symbol within each sub-frame accounts approximately for an average value of 30 % of the maximum rated power of the cell. This corresponds to a fixed PDCCH pattern of 72 transmitted REs at 10 MHz and 144 REs at 20 MHz.

    - REs dedicated to PHICH shall not be transmitted.

- **For busy hour load:**

  - All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH shall be limited as following:

    - Only a certain number of PRBs dedicated to PDSCH shall be transmitted. The number of transmitted PRBs dedicated to PDSCH shall be calculated as such, for 10 MHz bandwidth 25 PRBs and for 20 MHz bandwidth 50 PRBs.

    - As for the PDSCH, the amount of transmitted control channel resources shall be such that the power of the first OFDM symbol within each sub-frame accounts approximately for an average value of 50 % of the maximum rated power of the cell. This corresponds to a fixed PDCCH pattern of 144 transmitted REs at 10 MHz and 288 REs at 20 MHz.

    - REs dedicated to PHICH shall not be transmitted.

- **For full load:**

    - All Transmit Time Intervals (TTI) and resource blocks shall be transmitting, i.e. fully according to E-TM1.1.

For configurations with multiple transmitters operating on the same frequency (MIMO) each transmitter shall transmit the load as described in Table D.3.

Table D.3: Load model for LTE

	Low load	Medium load	Busy hour load
RF load for 3 sector with single 10 MHz carrier configuration. (1 TX & 2 RX path per sector active, 1 x 10 MHz carrier per TX).	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PDCCH, PHICH and PDSCH shall not be transmitted.	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PHICH shall not be transmitted. For the PDCCH, 72 further REs shall be transmitted within the first OFDM symbol of each sub-frame. In addition a certain number of PRBs dedicated to PDSCH shall be transmitted. The average number of transmitted PRBs dedicated to PDSCH shall be 15 PRBs per subframe where averaging is done over the 10 ms radio frame.	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PHICH shall not be transmitted. For the PDCCH, 144 further REs shall be transmitted within the first OFDM symbol of each sub-frame. In addition a certain number of PRBs dedicated to PDSCH shall be trans-mitted. The average number of trans-mitted PRBs dedicated to PDSCH shall be 25 PRBs per subframe where averaging is done over the 10 ms radio frame.
RF load for 3 sector with single 20 MHz carrier config. (1 TX & 2 RX path per sector active, 1 x 20 MHz carrier per TX).	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PDCCH, PHICH and PDSCH shall not be transmitted.	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PHICH shall not be transmitted. For the PDCCH, 144 further REs shall be transmitted within the first OFDM symbol of each sub-frame. In addition a certain number of PRBs dedicated to PDSCH shall be transmitted. The average number of transmitted PRBs dedicated to PDSCH shall be 30 PRBs per subframe where averaging is done over the 10 ms radio frame.	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PHICH shall not be transmitted. For the PDCCH, 288 further REs shall be transmitted within the first OFDM symbol of each sub-frame. In addition a certain number of PRBs dedicated to PDSCH shall be trans-mitted. The average number of trans-mitted PRBs dedicated to PDSCH shall be 50 PRBs per subframe where averaging is done over the 10 ms radio frame.
RF load for 3 sector with 2×2 MIMO 10 MHz carrier config. (2 TX & 2 RX path per sector active, 1 x 10 MHz carrier per TX).	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PDCCH, PHICH and PDSCH shall not be transmitted.	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PHICH shall not be transmitted. For the PDCCH, 72 further REs shall be transmitted within the first OFDM symbol of each sub-frame. In addition a certain number of PRBs dedicated to PDSCH shall be transmitted. The average number of transmitted PRBs dedicated to PDSCH shall be 15 PRBs per subframe where averaging is done over the 10 ms radio frame.	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PHICH shall not be transmitted. For the PDCCH, 144 further REs shall be transmitted within the first OFDM symbol of each sub-frame. In addition a certain number of PRBs dedicated to PDSCH shall be transmitted. The average number of transmitted PRBs dedicated to PDSCH shall be 25 PRBs per subframe where averaging is done over the 10 ms radio frame.

	Low load	Medium load	Busy hour load
RF load for 3 sector with 2×2 MIMO 20 MHz carrier config. (2 TX & 2 RX path per sector active, 1 x 20 MHz carrier per TX).	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PDCCH, PHICH and PDSCH shall not be transmitted.	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PHICH shall not be transmitted. For the PDCCH, 144 further REs shall be transmitted within the first OFDM symbol of each sub-frame. In addition a certain number of PRBs dedicated to PDSCH shall be transmitted. The average number of transmitted PRBs dedicated to PDSCH shall be 30 PRBs per subframe where averaging is done over the 10 ms radio frame.	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted. REs dedicated to PHICH shall not be transmitted. For the PDCCH, 288 further REs shall be transmitted within the first OFDM symbol of each sub-frame. In addition a certain number of PRBs dedicated to PDSCH shall be trans-mitted. The average number of transmitted PRBs dedicated to PDSCH shall be 50 PRBs per subframe where averaging is done over the 10 ms radio frame.

Frequency bands for LTE:

The frequency band shall be as defined in ETSI TS 136 104 [12], Table 5.5-1 E-UTRA frequency bands and according to equipment specifications. For measurement centre frequency of the specified band is used.

Annex E (normative):
Reference parameters for NR system

Reference configurations for NR shall be:

- Only normal cyclic prefix is used.

- For low load, medium load, and busy hour load, SS block (PBCH, PSS and SSS) shall be transmitted with a periodicity of 20 ms and a configured number of SS blocks per SSB set according to Table E.1. The configured number of SS blocks per SSB set shall be reported in the test report. In case of product comparisons, the tested products shall support the same configured number of SS blocks per SSB set during the test. SS block placement in the frequency domain can be freely selected according to the allowed synchronization rasters in ETSI TS 138 211 [18].

- For low load, medium load, and busy hour load, RMSI (SIB1) shall be transmitted with a repetition periodicity of 20 ms.

- PDCCH CCEs and PDSCH PRBs shall be configured as defined in NR-FR1-TM1.1 [16] and NR-FR2-TM1.1 [17] for FR1 and FR2, respectively.

- Usage of PDSCH PRBs and SS blocks can overlap for medium load and busy hour load. If so, in slots with SS blocks PDSCH shall be blanked/punctured in all PRBs which fall into the frequency range covered by the SS blocks.

- PDCCH CCE allocation can be selected freely for medium load and busy hour load.

- Placement of PDSCH PRBs for medium and busy hour load, can be selected freely within each 20 ms SSB set period. For examples, see annex J.

- No other physical channels and signals are transmitted.

- The same PRBs and PRB pattern shall be transmitted with each TX.

- RF output power level:

  - Power Range applicable to the "Wide Area BS" and "Medium Range BS" (for static measurements) classes as defined in ETSI TS 138 104 [15].

  - Maximum nominal RF output power at reference point (antenna connector for BS type 1-C, TAB connector for BS type 1-H, and RIB for BS types 1-O and 2-O) according to product specification and according to the load levels (Output power at reference point = load model based percentage × Maximum nominal RF output power) measured at the reference point according to ETSI TS 138 141-1 [16] and ETSI TS 138 141-2 [17], respectively.

  - For diversity and MIMO configurations: All TX shall transmit with equal transmit power.

  - For beamforming (AAS) configurations: Weight vectors to generate the beam pattern specified in clause 6.1.2 shall be applied.

- Power Input:

  - -48 V DC, 230 V AC, 400 V DC.

Table E.1: Allowed SS block and SSB set configurations

Frequency range	FR1 < 3 GHz	3 GHz < FR1 < 6 GHz	FR2
SS blocks per SSB set	1 - 4	1 - 8	1 - 64
SSB set periodicity [ms]	20	20	20

Downlink and uplink settings for NR TDD:

As specified for NR-FR1-TM1.1 in ETSI TS 138 141-1 [16] and NR-FR2-TM1.1 in ETSI TS 138 141-2 [17] for FR1 and FR2, respectively.

NR static load model:

The test model shall be according ETSI TS 138 141-1 [16] Test Model NR-FR1-TM1.1 and ETSI TS 138 141-2 [17] Test Model NR-FR2-TM1.1 for FR1 and FR2 respectively, with following adaptations:

- **For low load:**

  - All REs dedicated to PBCH, PSS, SSS (i.e. SS blocks, configurations according to Table E.1), and RMSI shall be transmitted.

  - REs dedicated to PDCCH and PDSCH (except RMSI) shall not be transmitted.

- **For medium load:**

  - All REs dedicated to PBCH, PSS, SSS (i.e. SS blocks, configurations according to Table E.1), and RMSI shall be transmitted.
    REs dedicated to PDCCH and PDSCH shall be limited as following:

    - 30 % of PRBs dedicated to PDSCH (in addition to RMSI) shall be transmitted in each 20 ms SSB set period.

    - For PDCCH, an amount CCEs (groups of 6 PRBs) corresponding to 30 % of available PDCCH resources in NR-TM1.1 shall be transmitted in each 20 ms SSB set period.

    - Placement of PDSCH PRBs within the 20 ms SSB set period is free, but the average load over the period shall be 30 %.

- **For busy hour load:**

  - All REs dedicated to PBCH, PSS, SSS (i.e. SS blocks, configurations according to Table E.1), and RMSI shall be transmitted.

  - REs dedicated to PDCCH and PDSCH shall be limited as following:

    - 50 % of PRBs dedicated to PDSCH (in addition to RMSI) shall be transmitted in each 20 ms SSB set period.

    - For PDCCH, an amount CCEs (groups of 6 PRBs) corresponding to 50 % of available PDCCH resources in NR-TM1.1 shall be transmitted in each 20 ms SSB set period.

    - Placement of PDSCH PRBs within the 20 ms SSB set period is free, but the average load over the period shall be 50 %.

- **For full load:**

  - All resource blocks shall be transmitting, i.e. fully according to NR-TM1.1. This means no SS blocks and no RMSI shall be configured.

For configurations with multiple transmitters (TX) operating on the same frequency, each TX shall transmit the same PRBs and PRB pattern.

Frequency bands for NR:

The frequency band shall be as defined in ETSI TS 138 104 [15], clause 5.2 Operating bands, and according to equipment specifications. For measurement centre frequency of the specified band is used.

Annex F (normative):
Reference parameters for multi-standard system

Table F.1: Load model for GSM 222 + WCDMA 111 case

	Low load	Medium load	Busy hour load
Load for 222 GSM	BCCH: Figure B.1 Other TRX: Idle	BCCH: Figure B.1 Other TRX: Idle	BCCH: Figure B.1 (TRX 1) Other TRX: 2 active TS per each sector at static power level. Other TS idle
Load for 111 WCDMA	Only Primary CPICH (10 % RF load)	CCH + first 3 codes (30 % RF load)	CCH + first 15 codes (50 % RF load)

Table F.2: Load model for GSM 222 + LTE 111/20 MHz (2×2 MIMO) case

	Low load	Medium load	Busy hour load
Load for 222 GSM	BCCH: Figure B.1 Other TRX: Idle	BCCH: Figure B.1 Other TRX: Idle	BCCH: Figure B.1 (TRX 1) Other TRX: 2 active TS per each sector at static power level. Other TS idle
Load for 111 20 MHz and 2×2 MIMO LTE	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH shall not be transmitted. (10 % RF load)	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH with 30 PRBs (30 % RF load)	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH with 50 PRBs (50 % RF load)

Table F.3: WCDMA 111 case + LTE 111/20 MHz (2×2 MIMO) case

	Low load	Medium load	Busy hour load
Load for 111 WCDMA per cell	Only Primary CPICH (10 % RF load)	CCH + first 3 codes (30 % RF load)	CCH + first 15 codes (50 % RF load)
Load for 111 20 MHz and 2×2 MIMO LTE	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH shall not be transmitted. (10 % RF load)	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH with 30 PRBs (30 % RF load)	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH with 50 PRBs (50 % RF load)

Table F.4: LTE 111/10 MHz (2×2 MIMO) + NR 111/10 MHz (2×2 MIMO) case

	Low load	Medium load	Busy hour load
Load for 111 10 MHz and 2×2 MIMO LTE	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH shall not be transmitted. (10 % RF load)	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH with 15 PRBs (30 % RF load)	All REs dedicated to PCFICH, reference- and synchronization signals shall be transmitted (as E-TM1.1). REs dedicated to PDCCH, PHICH and PDSCH with 25 PRBs (50 % RF load)
Load for 111 10 MHz and 2×2 MIMO NR	All REs dedicated to PBCH, PSS, SSS (i.e. SS blocks, configurations according to Table E.1), and RMSI shall be transmitted. REs dedicated to PDCCH and PDSCH (except RMSI) shall not be transmitted	All REs dedicated to PBCH, PSS, SSS (i.e. SS blocks, configurations according to Table E.1), and RMSI shall be transmitted. REs dedicated to PDCCH (according to annex E, medium load) and PDSCH corresponding to 30 % of PDSCH PRB load (in addition to RMSI), shall be transmitted in each 20 ms SSB set period	All REs All REs dedicated to PBCH, PSS, SSS (i.e. SS blocks, configurations according to Table E.1), and RMSI shall be transmitted. REs dedicated to PDCCH (according to annex E, busy hour load) and PDSCH corresponding to 50 % of PDSCH PRB load (in addition to RMSI), shall be transmitted in each 20 ms SSB set period

Other load combination than those described above
(for example: GSM 444 + WCDMA 111, or GSM 444 + LTE 111/20 MHz (2×2 MIMO), etc.):

- The RF sharing test shall be based on combinations of test cases specified for GSM, WCDMA, LTE or NR according to annexes B, C, D and E.

Annex G (normative):
Uncertainty assessment

G.0   Introduction

The wireless network efficiency data produced by the methods detailed in the present document will be subject to uncertainty due to the tolerance of measurement procedures or variance of real installations to the standard models suggested. The uncertainty of the measured parameters can be evaluated and will therefore provide comparable data, whilst that of the models used is subjective and should be assigned a sensitivity to assess significance.

G.1   General requirements

The assessment of uncertainty in the measurement of the static power consumption and energy efficiency of a base station shall be based on the general rules provided by the IEC/ISO Guide 98-3 [i.2].

Uncertainty factors are grouped into two categories according to the method used to estimate their numerical value:

- Type A: Those which are evaluated by statistical means.

- Type B: Those which are evaluated by other means, usually by scientific judgment using information available.

When a *Type A* analysis is performed, the standard uncertainty u_i shall be derived from the estimate from statistical observations.

When *Type B* analysis is performed, the standard uncertainty u_i is derived from the parameter $a = (a_+ - a_-)/2$, where a_+ is the upper limit and a_- is the lower limit of the measured quantity, and taking into account the distribution law of measured quantity, as follows:

- Normal law: $u_i = a/k$ where k is a coverage factor.

- U-shaped (asymmetric) law: $u_i = a/\sqrt{2}$.

- Rectangular law: $u_i = a/\sqrt{3}$ (default value to be used in the absence of any other information).

- Triangular law: $u_i = a/\sqrt{6}$ (not used in the present document).

G.2 Components contributing to uncertainty

G.2.0 Introduction

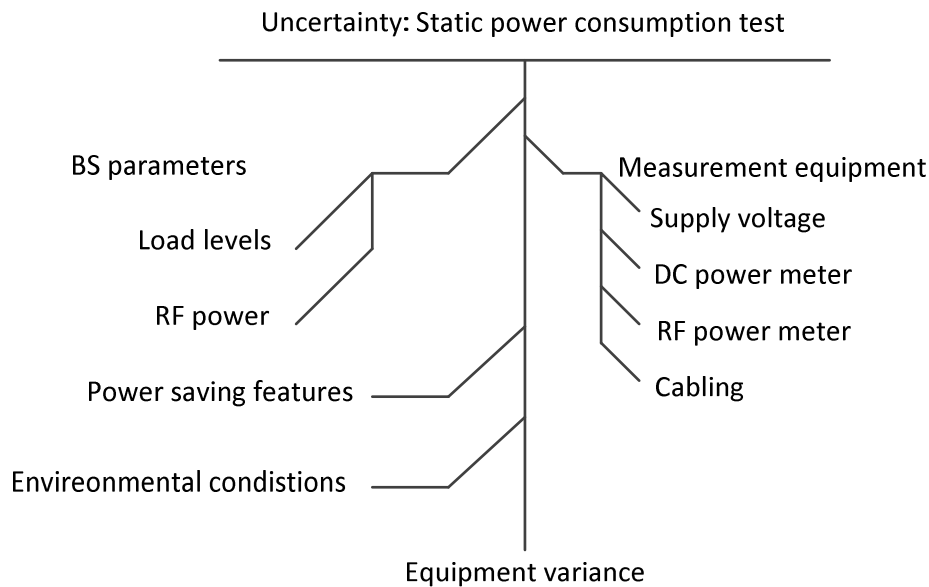The factors contributing to uncertainty are schematically shown in the uncertainty tree in Figure G.1.

Uncertainty: Static power consumption test

BS parameters

Load levels

RF power

Power saving features

Envireonmental condistions

Measurement equipment

Supply voltage

DC power meter

RF power meter

Cabling

Equipment variance

Figure G.1: Uncertainty tree - static power test

G.2.1 Contribution of the measurement system

G.2.1.1 Measurement equipment

The uncertainty contributed by the measurement equipment, e.g. voltmeter, power meter, RF power meter equipment shall be assessed with reference to its calibration certificates. The uncertainty due to the measurement equipment shall be evaluated assuming a type B normal probability distribution.

G.2.1.2 Attenuators, cables

The uncertainty contributed by the attenuator, shall be assessed with reference to its calibration certificates. The uncertainty due to the attenuator shall be evaluated assuming a Type B normal probability distribution.

G.2.2 Contribution of physical parameters

G.2.2.1 Impact of environmental parameters

The impact of environmental parameters (mainly temperature) is assessed taking into account temperature variation during the measurement period. It has to be assured that the DUT has reached stable conditions as defined in clause 5.2.3. The uncertainty shall be evaluated assuming a Type B rectangular probability distribution.

G.2.3 Variance of device under test

Based on component variances the individual base stations will have a certain deviations from the nominal value. The tested base station shall represent the nominal performance. The product to product efficiency spread is not considered in this uncertainty analysis but additional results on product efficiency spread might be provided.

G.3   Uncertainty assessment

G.3.1   Combined and expanded uncertainties

The contributions of each component of uncertainty shall be registered with their name, probability distribution, sensitivity coefficient and uncertainty value. The results shall be recorded in a table of the following form. The combined uncertainty shall then be evaluated according to formula (G.1):

$$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$$

(G.1)

where c_i is the weighting coefficient.

The expanded uncertainty shall be evaluated using a confidence interval of 95 % using the templates defined in Table G.1.

Table G.1: Uncertainty analysis for static assessment

ERROR SOURCES	Description (clauses)	Uncertainty Value (%)	Probability Distribution	Divisor	c_i	Standard Uncertainty (%)
Measurement Equipment						
Supply voltage	G.2.1.1		Normal	1	1	
Power consumption/DC power meter	G.2.1.1		Normal	1	1	
RF power/RF power meter	G.2.1.1		Normal	1	1	
Cabling, Attenuators	G.2.1.2		Normal	1	1	
Physical Parameters						
Environment conditions (T)	G.2.2.1	5 %	Rectangular	$\sqrt{3}$	0,5	
BS parameters			n/a			
Equipment variance	G.2.3	-	Gaussian			
Combined standard uncertainty			$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$			
Expanded uncertainty (confidence interval of 95 %)			**Normal**			$u_e = 1{,}96\, u_c$

G.3.2   Cross correlation of uncertainty factors

Cross correlations of above uncertainty factors are not considered if not otherwise stated.

G.3.3   Maximum expanded uncertainty

The expanded uncertainty with a confidence interval of 95 % shall not exceed 10 % for static tests and 20 % for dynamic tests.

If the expanded uncertainty is exceeding this target, then the uncertainty shall be added to the measured results.

Annex H (informative):
Example assessment

This annex presents results of a fictive assessment for 900 MHz GSM system. The system reference parameters are listed in Table H.1, the selected load distribution profile in Table H.2, and results in Tables H.3, H.4 and H.5.

Table H.1: Reference parameters of fictive 900 MHz GSM BS

Parameter	Value	Unit
1) BS configuration		
1.1) Number of sectors	3	
1.2) Nominal max RF output power per sector	40	W
1.3) Number of Carriers or TRXs per sector		
1.3.1) Number of carriers the BS is able to support	4	
1.3.2) Number of carriers, for which the HW was enabled (independent whether or not the carriers were used for the test)	3 x 2	
1.3.3) Number of carriers used during the test	2	
1.4) TX diversity	Cross polar antenna	
1.5) RX diversity	Two way diversity	
1.6) Type of RF signal combining	Air combining with cross polar antenna	
1.7) Remote Radio Head (Yes/No)		
1.8) Number of SS blocks per SSB set (only for NR)		
2) Frequency		
2.1) Downlink band	925 to 960	MHz
2.2) Uplink band	880 to 915	MHz
2.3) Channel bandwidth	0,20	MHz
2.4) Sub-carrier spacing (only for NR)	NA	kHz
3) Environment		
3.1) Temperature range	-33 to +40	°C
3.2) Type of air filter	NA	
4) Features		
4.1) Power saving features	None	
4.2) Coverage and capacity features	None	
4.3) Downlink ciphering used? (Y/N)		

Table H.2: Daily load distribution profile to be reported

Load level duration	Value	Unit
1) Low load duration/day (t_{low})	6	h
2) Medium load duration/day (t_{med})	10	h
3) Busy hour duration/day (t_{BH})	8	h
NOTE: Selected values sum to 24 h, as required in clause 7.1.		

Table H.3: Measurements conditions and results of fictive 900 MHz GSM BS

Parameter	Test case 25 °C	Test case 40 °C	Unit
1) Test environment			
1.1) Temperature during test (measured)	25,3	40,2	°C
1.2) Pressure (measured)	102,5	102,6	kPa
1.3) Relative humidity (measured)	41 %	46 %	
2) Downlink frequency used at test			
2.1) Centre frequency of low end channel	925,1	925,1	MHz
2.2) Centre frequency of middle channel	942,5	942,5	MHz
2.3) Centre frequency of high end channel	959,9	959,9	MHz
2.4) Uplink centre frequency of middle channel	897,5	897,5	MHz
3) Supply voltage			
3.1) DC voltage (measured)	54,0	54,0	V
3.2) AC voltage (measured, phase to neutral)	NA	NA	V
3.3) AC Frequency (measured)	NA	NA	Hz
4) Power consumption (measured)			
4.1) Full load, Middle frequency channel	840	860	W
4.2) Busy hour load, Middle frequency channel	819	840	W
4.3) Medium load, Middle frequency channel	681	698	W
4.4) Low load			
4.4.1) Low end frequency channel	642	663	W
4.4.2) Middle frequency channel	640	661	W
4.4.3) High end frequency channel	644	665	W
4.4.4) Average consumption with low load	642	663	W
5) TX output power (pilot signal only)			
5.1) Output power at low end channel	41,7	41,7	W
5.2) Output power at middle end channel	41,8	41,8	W
5.3) Output power at high end channel	41,6	41,6	W
5.4) Average output power per sector	41,7	41,7	W
6) RX receiver sensitivity at middle channel	-113,0	-113,0	dBm
7) Expanded uncertainty	17	17	%

Table H.4: Assessment power results for fictive 900 MHz GSM BS

Parameter	Value	Unit
1) $P_{equipment}$ of integrated BS power consumption at 25 °C	717	W
2) $P_{equipment}$ of integrated BS power consumption at 40 °C	737	W
3) $P_{equipment}$ of distributed BS power consumption at 25 °C	717	W
3.1) $P_{equipment}$ of distributed BS power consumption at 25 °C for central part	207	W
3.2) $P_{equipment}$ of distributed BS power consumption at 25 °C for remote part	510	W
4) $P_{equipment}$ of distributed BS power consumption at 40 °C	737	W
4.1) $P_{equipment}$ of distributed BS power consumption at 40 °C for central part	210	W
4.2) $P_{equipment}$ of distributed BS power consumption at 40 °C for remote part	527	W

Table H.5: Assessment daily energy results for fictive 900 MHz GSM BS

Parameter	Value	Unit
1) $E_{equipment}$ of integrated BS energy consumption at 25 °C	17 208	Wh
2) $E_{equipment}$ of integrated BS energy consumption at 40 °C	17 688	Wh
3) $E_{equipment}$ of distributed BS energy consumption at 25 °C	17 208	Wh
3.1) $E_{equipment}$ of distributed BS energy consumption at 25 °C for central part	4 968	Wh
3.2) $E_{equipment}$ of distributed BS energy consumption at 25 °C for remote part	12 240	Wh
4) $E_{equipment}$ of distributed BS energy consumption at 40 °C	17 688	Wh
4.1) $E_{equipment}$ of distributed BS energy consumption at 40 °C for central part	5 040	Wh
4.2) $E_{equipment}$ of distributed BS energy consumption at 40 °C for remote part	12 648	Wh

Annex I (informative):
Interpolation method

The present document describes specific load levels for the static power consumption test (clause 6). Other load levels may be occasionally of interest. When power saving features are not activated, power consumption at other load levels can be assessed by interpolation from P_{FL}, P_{BH}, P_{med}, P_{low} measured values taking a quadratic function or a linear interpolation.

The relation between load levels and power consumption of a BS is typically linear as international research projects demonstrated. For example, the OPERA-net and EARTH projects described in ETSI TR 103 117 [i.9] proposed BS power models with a linear approach. Practical measurements show a quite linear relation between load and power consumption between low and full load.

The following linear model based on the power consumption at full load (P_{FL}), busy hour (P_{BH}), medium load (P_{med}) and low load (P_{low}) as defined in clause 6, may be applied to calculate power consumption at other load levels:

$$P(P_{RF}) = P_{low} + c \cdot P_{RF} \tag{I.1}$$

with:

- P_{low} = power consumption with low load level

- c = a constant calculated to achieve a best fit with the measured P_{RF} values for full load (P_{FL}), busy hour (P_{BH}), medium load (P_{med}) and low load (P_{low})

- P_{RF} = transmitted RF power

In the case that the measured four load levels indicate a significant deviation from a linear function, a quadratic model might be applied to optimally match the interpolation curve with the tested values, in particular for low loads.

Annex J (informative):
Load placement examples

The examples presented in this Annex are for illustrative purposes.

For the OFDM-based radio standards LTE and NR it is in annex D and annex E, respectively, stated for the medium load and busy hour load levels that "placement of PDSCH PRBs can be selected freely within the 10 ms radio frame" (for LTE) and "placement of PDSCH PRBs for medium and busy hour load can be selected freely within each 20 ms SSB set period" (for NR).

"Freely selected placement" means that the defined average PDSCH load (30 % for medium load and 50 % for busy hour load, respectively), calculated over the radio frame (for LTE) and the SSB set period (for NR), can be freely distributed over the PRBs in the radio frame (or SSB set period). Examples with 30 % PDSCH load are provided in Figure J.1 to Figure J.3 for LTE, and in Figure J.4 to Figure J.7 for NR.
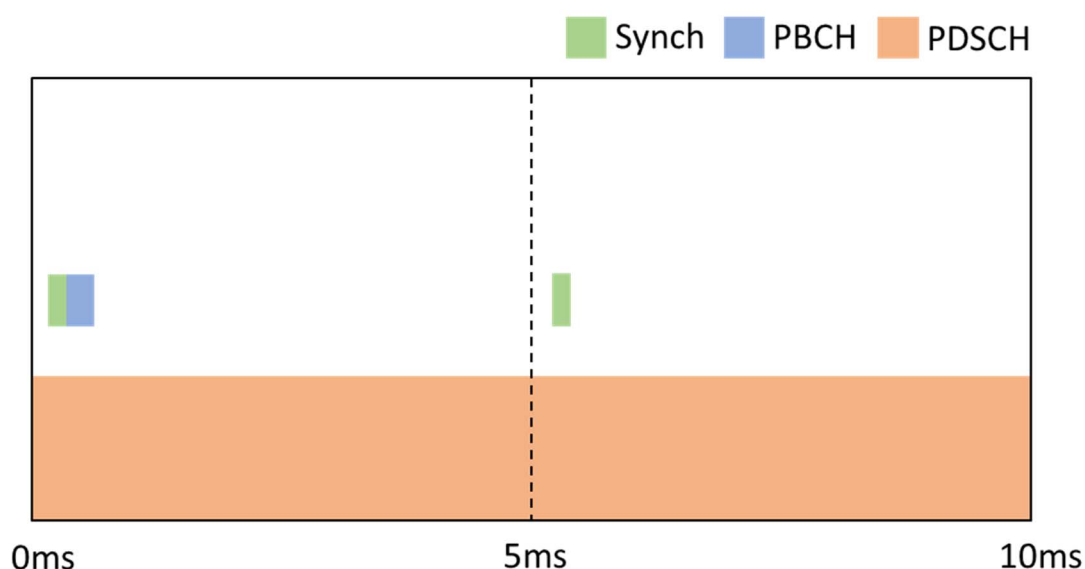
**Figure J.1: Example of LTE PDSCH medium load equally distributed in time
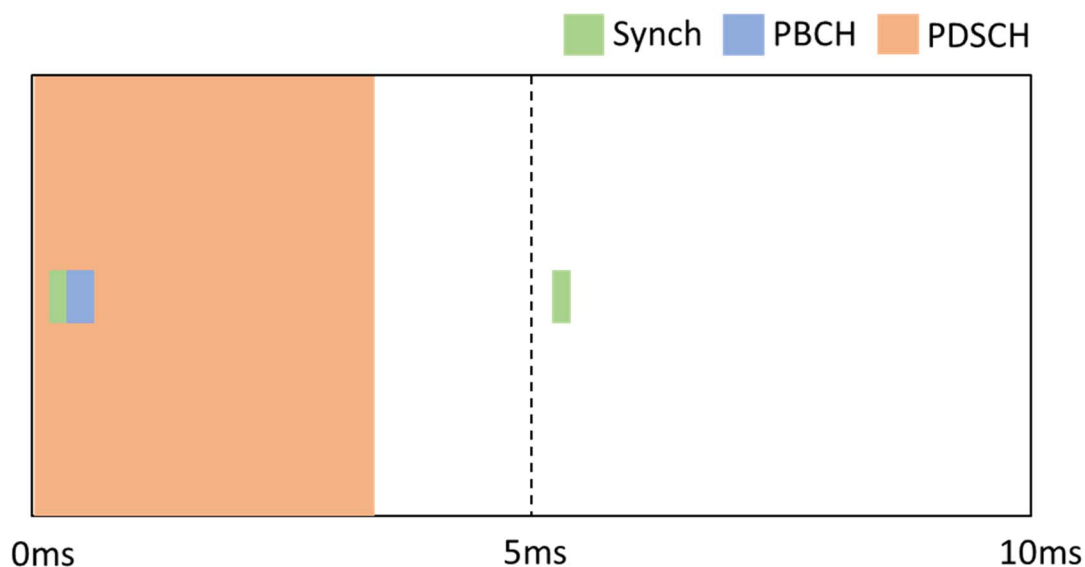(used bandwidth is constant)**

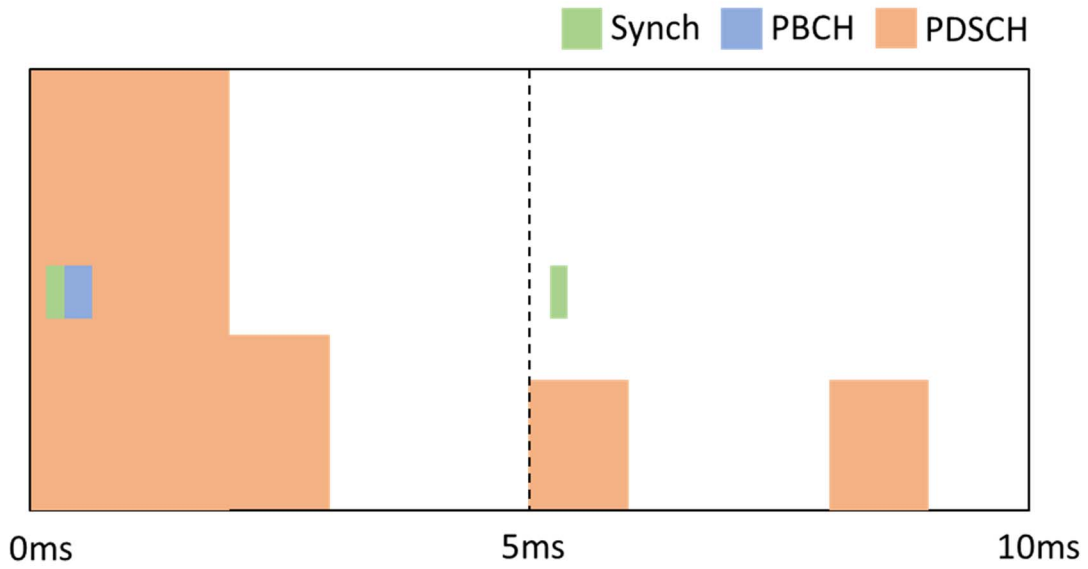**Figure J.2: Example of LTE PDSCH medium load concentrated in time, but using the full bandwidth**

Figure J.3: Example of LTE PDSCH medium load distributed in time and frequency
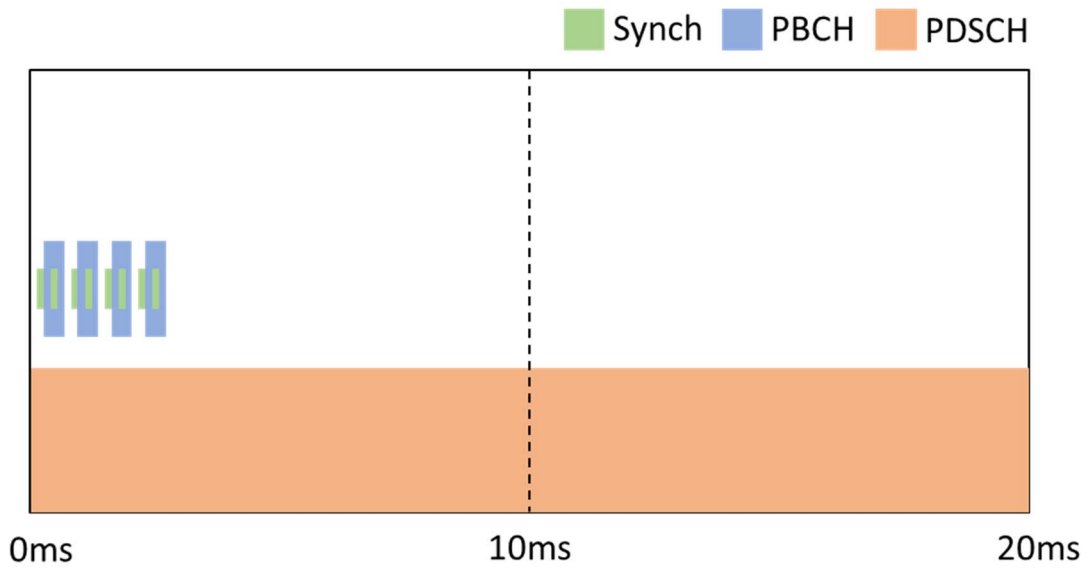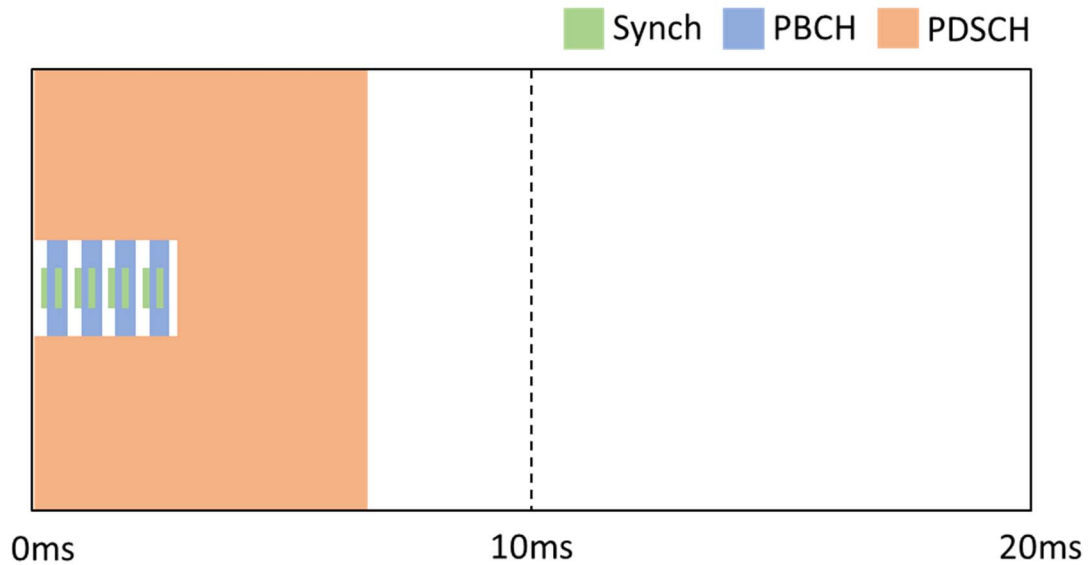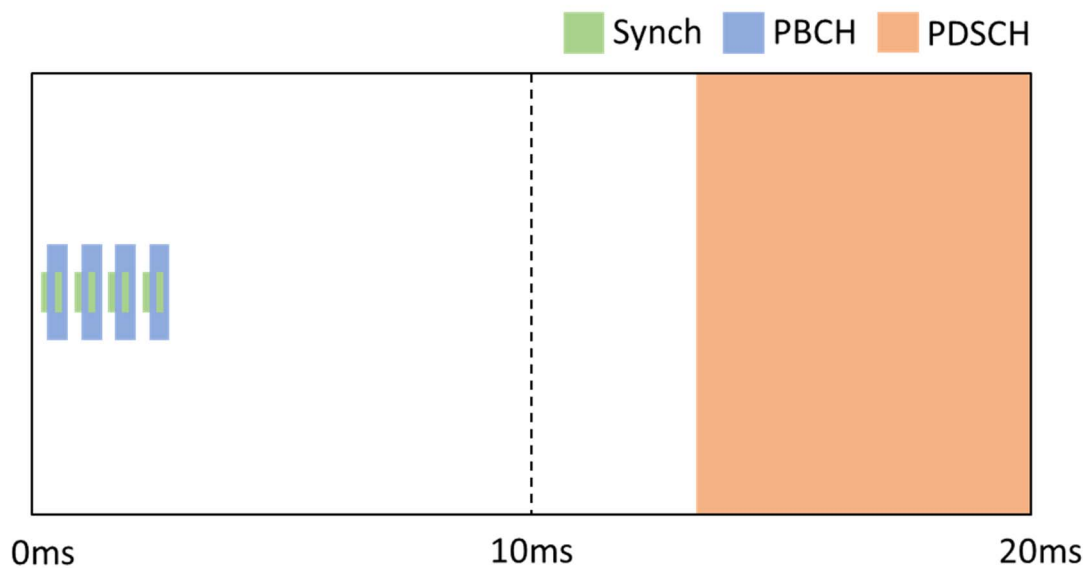

Figure J.4: Example of NR PDSCH medium load equally distributed in time (used bandwidth is constant)

NOTE: In slots with SS blocks, the PDSCH PRBs which fall into the frequency range covered by the SS blocks
         are punctured.

**Figure J.5: Example of NR PDSCH medium load concentrated in the beginning of
the SSB period, but using the full bandwidth**

NOTE: In this example, there is no overlap of PDSCH and SS blocks and hence no puncturing of PDSCH PRBs is
         required.

**Figure J.6: Example of NR PDSCH medium load concentrated in the end of
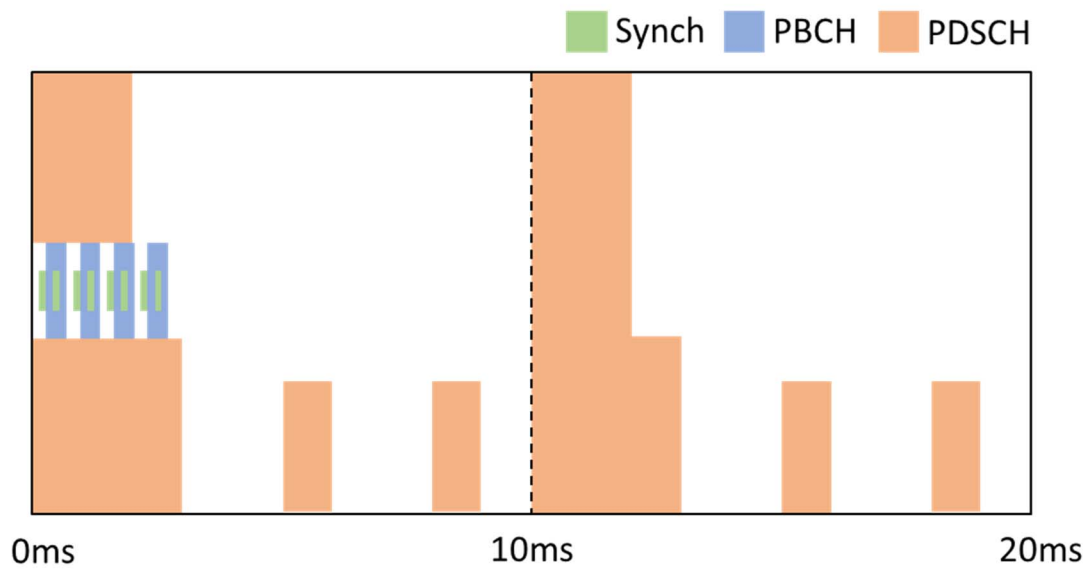the SSB period, but using the full bandwidth**

Figure J.7: Example of NR PDSCH medium load distributed in time and frequency

All these examples (and other distributions) are allowed, as long as the PDSCH load in the radio frame (for LTE) and the SSB set period (for NR) is the same (in this case 30 %).

Annex K (informative):
Bibliography

- NIST Technical Note 1297: "Guidance for evaluating and expressing the uncertainty of NIST measurement results".

Annex L (informative):
Change history

Date	Version	Information about changes
March 2024	1.7.6	Update of Annex J adding other slot level load model examples

History

Document history		
V1.1.1	August 2009	Publication as ETSI TS 102 706
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