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Sustainable power feeding solutions for 5G network

Reference

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Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE), and is now submitted for the ETSI standards Membership Approval Procedure.

Modal verbs terminology

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Executive summary

The present document defines power feeding solutions for 5G, converged wireless and wireline access equipment and network, taking into consideration their enhanced requirements on service availability and reliability, the new deployment scenarios, together with the environmental impact of the proposed solutions.

The minimum requirements of different solutions including power feeding structures, components, backup, safety requirements, environmental conditions are also defined.

The present document is applicable to powering of both mobile and fixed access network elements, in particular on equipment that have similar configurations and needs.

Introduction

Mobile and fixed networks are evolving towards ultra-broadband and, with 5G, are going to converge. The use of much broader frequency ranges, up to 60 GHz, where radio propagation is an issue, is going to impact the network deployment topologies. In particular, the use of higher frequencies and the need to cover hot/black spots and indoor locations, will make it necessary to deploy much denser amount of radio nodes.

5G is introducing major improvements on Massive MIMO, IoT, low latency, unlicensed spectrum, and with V2x for the vehicular market. Support of some of these services will have a relevant effect on the power ratings and the energy consumption at the radio base station.

A major new service area of 5G impacting the powering and backup will be the URLLC (Ultra Reliable Low Latency Communication) as its support will increase the service availability demands by many orders of magnitude. Supporting such high availability goals will be partly reached through redundant network coverage, but a main support will have to come through newly designed powering architectures. This will be made even more challenging as 5G will require the widespread introduction of distributed small cells. ETSI TS 110 174-2-2 [i.5] analyses the implications and indicates possible solutions to fulfil such high demanding availability goals.

There is a need to define sustainable and smart powering solutions, able to adapt to the present mobile network technologies and able to evolve to adapt to their evolution. The flexibility would be needed at level of power interface, power consumption, architecture tolerant to power delivery point changes and including control-monitoring.

This means that it should include from the beginning appropriate modularity and reconfiguration features for local powering and energy storage and for remote powering solutions including power lines sizing, input and output conversion power and scalable sources.

A technically equivalent of the present document is jointly developed by ITU-T as Recommendation ITU-T L.1210 [i.7].

1 Scope

The present document defines power feeding solutions for 5G, converged wireless and wireline access equipment and network, taking into consideration their enhanced requirements on service availability and reliability, the new deployment scenarios, together with the environmental impact of the proposed solutions.

The minimum requirements of different solutions including power feeding structures, components, backup, safety requirements, environmental conditions are also defined.

The present document is applicable to powering of both mobile and fixed access network elements, in particular on equipment that have similar configurations and needs.

The future development of 5G networks will create a new scenario in which the density of radio cells will increase considerably, together with the increase of wireline network equipment that are going to be installed in the vicinity to the users, thereby creating the need to define new solutions for powering that will be environmentally friendly, sustainable, dependable, smart and visible remotely.

The -48 V DC, up to 400 V DC local and remote power solutions defined respectively in ETSI EN 300 132-2 [2], ETSI EN 302 099 [4] and ETSI EN 300 132-3-1 [3] or Recommendation ITU-T L.1200 [8] will be considered as the standards in force for power facilities, together with IEEE 802.3 [14] (PoE).

2 References

2.1 Normative references

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

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

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

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

[1] ETSI EN 300 132-1 (V2.1.1) (03-2019): "Environmental Engineering (EE); Power supply interface at the input to Information and Communication Technology (ICT) equipment; Part 1: Alternating Current (AC)".

[2] ETSI EN 300 132-2 (V2.6.1) (04-2019):"Environmental Engineering (EE); Power supply interface at the input of Information and Communication Technology (ICT) equipment; Part 2: -48 V Direct Current (DC)".

[3] ETSI EN 300 132-3-1 (V2.1.1) (02-2012): "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V; Sub-part 1: Direct current source up to 400 V".

[4] ETSI EN 302 099 (V2.1.1) (08-2014): "Environmental Engineering (EE); Powering of equipment in access network".

[5] ETSI ES 203 199 (V1.3.1) (02-2015): "Environmental Engineering (EE); Methodology for environmental Life Cycle Assessment (LCA) of Information and Communication Technology (ICT) goods, networks and services".

[6] ETSI TS 103 553-1: "Environmental Engineering (EE); Innovative energy storage technology for stationary use; Part 1: Overview".

[7] Recommendation ITU-T L.1001 (11/2012): "External universal power adapter solutions for stationary information and communication technology devices".

[8] Recommendation ITU-T L.1200 (05/2012): "Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment".

[9] Recommendation ITU-T L.1220 (08/2017): "Innovative energy storage technology for stationary use - Part 1: Overview of energy storage".

NOTE: Available at https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13283.

[10] Recommendation ITU-T L.1221 (11/2018): "Innovative energy storage technology for stationary use - Part 2: Battery".

[11] Recommendation ITU-T L.1222 (05/2018): "Innovative energy storage technology for stationary use - Part 3: Supercapacitor technology".

[12] Recommendation ITU-T L.1350 (10/2016): "Energy efficiency metrics of a base station site".

[13] Recommendation ITU-T L.1410 (12/2014): "Methodology for environmental life cycle assessments of information and communication technology goods, networks and services".

[14] IEEE 802.3™-2018: "IEEE Standard for Ethernet".

[15] IEEE 802.3bt™-2018: "IEEE Standard for Ethernet Amendment 2: Physical Layer and Management Parameters for Power over Ethernet over 4 pairs".

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.

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

[i.1] Recommendation ITU-T Q.1743 (09/2016): "IMT-Advanced references to Release 11 of LTE-Advanced evolved packet core network".

[i.2] ETSI ES 202 336-12: "Environmental Engineering (EE); Monitoring and control interface for infrastructure equipment (power, cooling and building environment systems used in telecommunication networks); Part 12: ICT equipment power, energy and environmental parameters monitoring information model".

[i.3] ETSI EN 301 605 (V1.1.1) (2013-10): "Environmental Engineering (EE); Earthing and bonding of 400 V DC data and telecom (ICT) equipment".

[i.4] ETSI TS 122 261: "5G; Service requirements for next generation new services and markets (3GPP TS 22.261)".

[i.5] ETSI TS 110 174-2-2: "Access, Terminals, Transmission and Multiplexing (ATTM); Sustainable Digital Multiservice Cities; Broadband Deployment and Energy Management; Part 2: Multiservice Networking Infrastructure and Associated Street Furniture; Sub-part 2: The use of lamp-posts for hosting sensing devices and 5G networking".

[i.6] Recommendation ITU-T K.64 (06/2016): "Safe working practices for outside equipment installed in particular environments".

[i.7] Recommendation ITU-T L.1210: "Sustainable power feeding solutions for 5G networks".

[i.8] CENELEC EN 50173-1: "Information technology - Generic cabling systems - Part 1: General requirement".

[i.9] IEEE 802.3cg™: "IEEE Approved Draft Standard for Ethernet Amendment 5: Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

cell: radio network object that can be uniquely identified by a user equipment from a (cell) identification that is broadcasted over a geographical area from one UTRAN or GERAN access point

NOTE 1: A Cell in UTRAN is either FDD or TDD mode.

NOTE 2: Available in Recommendation ITU-T Q.1743 [i.1].

cloud RAN: RAN functions are partially or completely centralizing with two additional key features: pooling of baseband/hardware resources, and virtualization through general-purpose processors

distributed RAN: network development where RAN processing is fully performed at the site as in 4G

macro cells: outdoor cells with a large cell radius

NOTE: Available in Recommendation ITU-T Q.1743 [i.1].

micro cells: small cells

NOTE: Available in Recommendation ITU-T Q.1743 [i.1].

pico cells: cells, mainly indoor cells, with a radius typically less than 50 metres

NOTE: Available in Recommendation ITU-T Q.1743 [i.1]

3.2 Symbols

Void.

3.3 Abbreviations

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

5G	fifth Generation
AAU	Active Antenna Unit
AC	Alternating Current
AI	Artificial Intelligence
BBU	Base Band Unit
BCS	Battery Control System
BMS	Battery Management System
BS	Base Station
C-RAN	Centralized or Cloud RAN
DC	Direct Current

NOTE: Also when used as a suffix to units of measurement.

DOD	Deep of Discharge
DP	Distribution Point
D-RAN	Distributed RAN
DSLAM	Digital Subscriber Line Access Multiplier
EV	Electrical Vehicle

FWA	Fixed Wireless Access
GND	GrouND
GPON	Gigabit Passive Optical Network
Hetnets	Heterogeneous network
ICT	Information Communication Telecommunication
IoT	Internet of things
LFP	Lithium Iron Phosphate
MEC	Multi-access Edge Computing
MIMO	Multi Input Multi Output
mmWaves	millimetric Waves
MPPT	Maximum Power Point Tracking
NE	Network Element
OS	Optical Splitter
PAV	Power Available Value
PN	Power Node
PON	Passive Optical Network
PS	Power Splitter
PSU	Power Supply Unit
PTU	Power Transmitter Unit
PV	PhotoVoltaic
PVC	PolyVinyl Chloride
RAN	Radio Access Network
REN	Renewable ENergy
RF	Radio Frequency
RRH	Remote Radio Head
RRU	Remote Radio Unit
SEE	Site Energy Efficiency
SELV	Safety Extra Low Voltage
SOC	Status Of Charge
SOH	Status Of Health
TDD	Time Division Duplex
TTM	Time To Market
URLLC	Ultra Reliable Low Latency Communication
UTRAN	Universal Terrestrial Radio Access Network
UV	UltraViolet

4 5G networks

4.1 5G Network general description

Figure 1 is presenting a general end to end schematics of 5G network to be powered.

It includes stationary and mobile equipment:

- Macro cell equipment BS for wide coverage. In most cases, they will be located in the same sites as the macro BS of the previous mobile generations. The increased energy demand and the much higher availability need of the 5G equipment will pose tough challenges to the powering infrastructure and will likely require its major upgrade both on the power capabilities and the backup duration.

- Small cell, to cover small geographical area in indoor/outdoor applications, typically to satisfy data traffic hot-spots, black-spots and to deliver services at very high frequencies (e.g. mmWaves) that could not be supported just through macro BS installations. Small cells can be subdivided into:

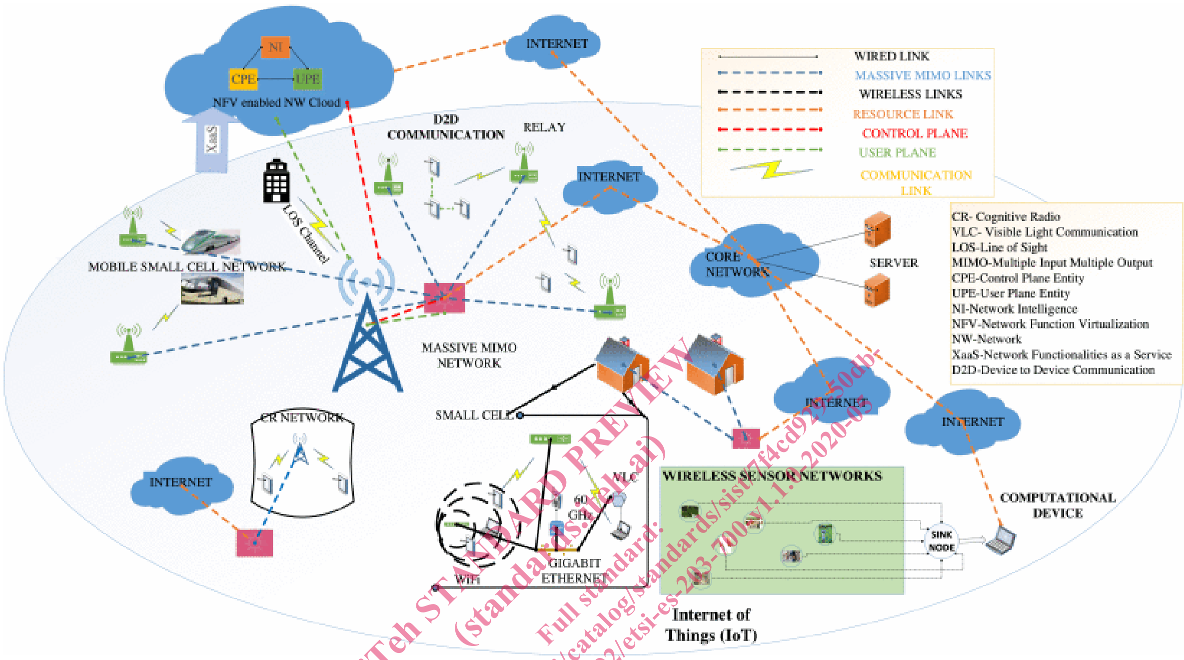
  - Micro cell - normally installed outdoors. Designed to support large number of users in high data traffic areas, to solve coverage issues and to support very high frequency deployment. Capable to cover medium/large cells size and suitable for application like smart cities, smart metro, etc.

  - Pico cell - normally installed indoors. Suitable for enterprises, shopping centres, stadiums applications, for extended network coverage and data throughput.

- Femto cell - basically small mobile base stations designed to provide extended coverage for residential and SoHo applications. Poor signal strength from mobile operator's base stations can be solved using Femtocell implementation. Femtocells are primarily introduced to offload network congestion, extend coverage and increase data capacity to indoor users.

- IoT devices and concentrators.
- In network cloud distribution including edge computing.

Also Fixed Wireless Access (FWA) radio access solutions, typically in point-to-multipoint configuration with coverage across macro and small cells schemes, will contribute to the evolution of ultra-broadband future networks.



Source: http://ieeexplore.ieee.org/document/7169508/.

Figure 1: General principle of a 5G cellular network architecture with interconnectivity among the different emerging technologies like Massive MIMO network, Cognitive Radio

4.2 Cells coverage and impacts on powering strategy

In the 4G era, a base station covers a radius of hundreds of meters, while a 5G base station operating at mmWave may cover only 20 to 40 meters, needing a much higher number of equipment to be spread-out in the field to guarantee appropriate coverage. More dense deployment will also be needed to cover high traffic areas (e.g. stadiums) and indoor locations. That could result in much higher network development complexity and costs. In addition, the deployment of additional base stations is difficult and the site resources are not easy to obtain. Therefore, 5G networks will see a major development of small cells, in the form of small base stations as the basic unit for ultra-intensive networking, that is, small base stations dense deployment. In the future, the most likely deployment mode for 5G base station construction will be low-frequency wide area coverage (macro base station) + high-frequency deep coverage (micro base station), as shown in Figures 2.

Figure 2(a): Deployment mode of the 5G base station

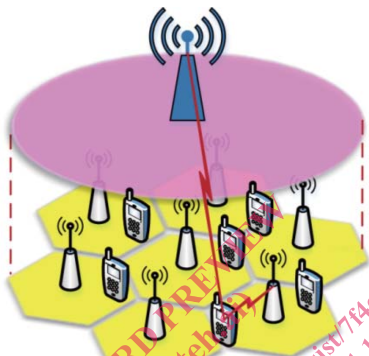


Figure 2(b): Micro base station

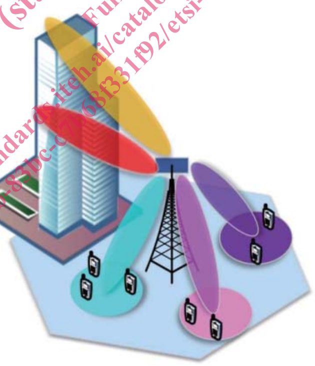


Figure 2(c): Macro base station

The typical electrical power demand for Radio Base Stations (macro cell, micro cell and pico or femto cell), with correlation to aggregated RF power, is available in Table 1, together with power needs of IoT, as they could be based on powering paradigms similar to those of the Small Cells.