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TECHNICAL REPORT

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Validation of dynamic power control and exposure time-averaging algorithms – Part 1: Cellular network implementations for SAR at frequencies up to 6 GHz

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VALIDATION OF DYNAMIC POWER CONTROL AND EXPOSURE TIME-AVERAGING ALGORITHMS –

Part 1: Cellular network implementations for SAR at frequencies up to 6 GHz

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IEC TR 63424-1 has been prepared by IEC technical committee 106: Methods for the assessment of electric, magnetic and electromagnetic fields associated with human exposure. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
106/658/DTR	106/673/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 63424 series, published under the general title *Validation of dynamic power control and exposure time-averaging algorithms*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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INTRODUCTION

The concept of dynamic power control and exposure time-averaging (DPC-ETA) has been introduced recently to enable wireless devices to maintain SAR compliance in real-time. DPC-ETA enables a SAR assessment that is more representative of the user exposure. The procedures in IEC/IEEE 62209-1528:2020 require device under test (DUT) to maintain a fixed output power and transmission duty factor during SAR measurement to establish the correct SAR distribution to determine SAR compliance. When devices are tested at a fixed maximum output power and transmission duty factor for worst-case exposure and continuous use, a reduction in maximum power is often necessary to satisfy SAR compliance. This can result in undesirable device performance with poor link budget and low data throughput.

In DPC-ETA, SAR compliance is determined according to power recorded by the RF modem and time-averaged over a specified window duration. Device output power control is based on the linear SAR to power relationship established for a wireless operating mode and specific exposure condition to maintain SAR compliance during actual use. When the maximum time-averaged power is ensured by DPC-ETA, brief durations of higher instantaneous power can be applied while the maximum time-averaged power is not exceeded.

NOTE 1 The time-averaging windows required by national regulations can be the same as those established for SAR limits or can differ and vary with frequency.

The DPC-ETA algorithms are validated using power control test sequences with conducted and radiated power measurement methods described in Annex A and Annex B. The criteria for correlating power measurement results with expected DPC-ETA behaviour of the test sequences are also described. The measurement system validation and system check considerations are discussed in Annex C. The correlation of radiated power and single-point SAR measurement is illustrated in Annex D. The SAR methods that can be applied instead of radiated power measurement are described in Annex F. Guidance for validation of capacitive proximity sensor triggering with time-averaged detection are provided in Annex E.

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NOTE 2 For the purposes of this document, test laboratories and users are referred to as user(s). This document provides recent information for users to address specific testing needs. It is possible that it is not able to provide solutions to all issues that are being identified or explored. The improvements realized from experiences in applying this document for DPC-ETA algorithm validation, including any adjustments needed to validate devices or comprehensive uncertainty analyses, that need further considerations, can be addressed in a subsequent revision of this document.

VALIDATION OF DYNAMIC POWER CONTROL AND EXPOSURE TIME-AVERAGING ALGORITHMS –

Part 1: Cellular network implementations for SAR at frequencies up to 6 GHz

1 Scope

This part of IEC 63424 describes the methods for validating dynamic power control and (dynamic) exposure time-averaging (DPC-ETA) algorithms used in RF modem chipsets of wireless devices. The DPC-ETA implementations are exposure-based, where SAR is time-averaged according to power recorded by the RF modem. Time-averaging windows up to six minutes consistent with applicable SAR limits and regulatory policies are considered for frequencies up to 6 GHz. The DPC-ETA power control parameters are established based on SAR compliance results with all relevant design and operating tolerances taken into consideration. The device output power is controlled by DPC-ETA to maintain SAR compliance in real-time. While SAR compliance is evaluated independently by applying IEC/IEEE 62209-1528:2020 [1][1], this document contains information for algorithm validation.

Quasi-static and dynamic power control test sequences are described in this document for algorithm validation. The test sequences are sent from a radio communication tester (RCT) and DPC-ETA responses are measured with conducted and radiated power measurement methods to confirm algorithm functionality. Test sequences for wireless configurations that need validation, including wireless mode transitions, call drop, handover, discontinuous transmission, and simultaneous transmission are described. Considerations for measurement automation to acquire time-aligned results for correlation with power changes in the test sequences are provided. DPC-ETA algorithms are validated by correlating the normalized power measurement results with the expected behaviours of an implementation for the applied test sequences. The procedures in this document also support algorithm validation of modular transmitters using an appropriate test platform. Guidance for using SAR methods in place of radiated power measurements and capacitive proximity sensor triggering with time-averaged detection are also included.

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NOTE 1 A separate document will be considered to validate DPC-ETA implementations above 6 GHz, according to near-field millimetre-wave band power density exposure requirements. Substantially shorter time-averaging window durations, on the order of a few seconds, can be required to satisfy some national regulatory requirements.

NOTE 2 The scope of this document is limited to cellular network technologies that have RF modem transmission power dictated by a base station and therefore can be tested using RCT test sequences. Cellular network technologies (also referred to as wireless wide area networks (WWAN)) include Global System for Mobile Communications (GSM), Universal Mobile Telecommunication System (UMTS), Long-Term Evolution (LTE) and 5G New Radio (NR), including other related 2G, 3G, 4G, and 5G specifications, respectively. A separate document will be considered for validating DPC-ETA implementations for wireless local area network (WLAN) technologies, such as those based on the IEEE 802.11 standards series. With WLAN technologies, the transmit power is dictated independently by the RF modem and can be specific to each power control implementation, requiring different testing approaches.

NOTE 3 The procedures in this document can also be considered for 3GPP [2] 5G NR FR1 bands above 6 GHz.

NOTE 4 This document does not address algorithm validation for simultaneous transmission configurations involving transmitters that are not controlled by DPC-ETA operations in the RF modem. These are evaluated according to regulatory requirements.

[1] Numbers in square brackets refer to the Bibliography.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
dynamic power control
DPC
power control algorithm used in RF modem chipset of wireless devices according to descriptions in this document

Note 1 to entry: Transmitter power control is based on power measured and recorded by the RF modem according to the linear SAR and power relationship of individual wireless mode configurations and exposure conditions to maintain time-averaged power below a specified threshold for continuous exposure and SAR compliance.

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3.2
exposure time-averaging
ETA
time-averaging algorithm used in RF modem chipset of wireless devices for calculating time-averaged exposure according to measured and recorded power

Note 1 to entry: The recorded power is time-averaged over a specified time window according to the SAR limit or regulatory requirements. The calculated time-averaged power is used in DPC-ETA implementations as feedback to adjust transmitter power dynamically in real-time. For the purposes of algorithm validation, simple arithmetic averaging, or other suitable types of averaging accepted by the regulator, are covered by the procedures in this document.

3.3
dynamic power control and exposure time-averaging
DPC-ETA
algorithms used in RF modem chipset of wireless devices according to 3.1 and 3.2 to ensure SAR compliance for continuous exposure based on time-averaged power over a specified time window duration

3.4
RF modem
wireless transceiver incorporated in the chipset of wireless devices that supports the wireless protocol and operations

Note 1 to entry: RF modems include, for example, GSM, UMTS, LTE, and 5G NR to support the wireless modes specified by 3GPP protocols.

3.5
wireless operating mode
wireless operating configurations used in RF modems, according to parameters defined by wireless protocols (e.g. 3GPP), for transmission within the wireless network and infrastructure

Note 1 to entry: The parameters include the RF channel frequency, channel bandwidth, signal modulation and other transmission protocol specifications (e.g. power requirements, carrier aggregation, etc.) for communication with other devices in the network.

3.6
proximity sensor
capacitive sensor or multiple capacitive sensors for detection of user proximity from the DUT, for the purpose of limiting transmitter power in order to ensure conformity with RF exposure limits

3.7
specific absorption rate
SAR
measure of the rate at which energy is absorbed by the human body when exposed to a radio frequency electromagnetic field

3.8
output power
power at the output of the RF transmitter when the antenna, or a load with the same input impedance as the antenna, is connected to it

3.9
conducted power
power delivered by the power amplifier of the device to 50 Ω matched load

Note 1 to entry: For the purposes of this document, conducted power is measured at the antenna port using equipment with 50 Ω input impedance.

3.10
power control algorithm
DPC-ETA protocol used in a DUT to set and adjust the output power of the transmitter to satisfy SAR compliance

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3.11
radiated power
power measured with the DUT transmitting using its built-in antenna while operating in an anechoic chamber, according to the DPC-ETA algorithm validation procedures described in this document

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3.12
time-averaging
averaging of power recorded by the RF modem or measured by test equipment over a specified time window

Note 1 to entry: The calculated time-averaged power is used by the RF modem for power control to ensure a maximum time-averaged power is not exceeded for continuous exposure.

3.13
maximum time-averaged output power
P_{limit}
maximum time-averaged power allowed for continuous exposure

Note 1 to entry: For the purposes of this document, a specified P_{limit} includes all tolerances that are relevant to DPC-ETA operations, which corresponds to a not-to-exceed value. The P_{limit} stored in the DUT is typically a nominal value without including the tolerance. The measured P_{limit} can be higher or lower than the nominal value, but within the specified DPC-ETA tolerance and does not exceed the specified P_{limit}.

3.14
time-averaging window
time window
Tw_{avg}
time interval used to calculate time-averaged power and determine time-averaged exposure

Note 1 to entry: For the purposes of this document, time-averaged exposure is determined according to the time-averaging requirements specified by SAR limits and regulatory policies. A frequency-dependent time-averaging window can be required by some national regulations.

3.15
maximum instantaneous output power
P_{max}
maximum output power a transmitter supports for the intended operations

Note 1 to entry: For algorithm validation, a specified P_{max} includes all tolerances relevant to DPC-ETA operations; i.e. it is a not-to-exceed value. The P_{max} stored in a DUT is typically the nominal value without including the tolerance. The measured P_{max} can be higher or lower than the nominal value, but within the specified DPC-ETA tolerance and does not exceed the specified P_{max}.

Note 2 to entry: Compare with IEC 60050-192:2015, 192-13-05: "instantaneous value: value of a time dependent variable at a given instant".

3.16
SAR target
$\boldsymbol{SAR}_{\mathbf{target}}$
peak spatial-average SAR value corresponding to the measured P_{limit} of a wireless operating mode and exposure condition

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Note 1 to entry: The tolerances for a measured P_{limit} also apply to the SAR_{target}.

3.17
SAR reported
$SAR_{reported}$

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peak spatial-average SAR value corresponding to the minimum (specified P_{limit}, specified P_{max}) obtained by scaling measured SAR_{target} associated with measured P_{limit} of a wireless operating mode and exposure condition.

3.18
optional output power threshold
P_{ctrl}
DPC-ETA power control parameter, in addition to P_{max} and P_{limit}

Note 1 to entry: Depending on the DPC-ETA implementation, it can be used to specify a low power threshold for power control or a minimum power level for power adjustment. This can be an internal parameter with no OEM access or not required at all for some implementations.

3.19
power control test sequence
test sequence described in this document for DPC-ETA algorithm validation

Note 1 to entry: Quasi-static and dynamic test sequences are used to validate algorithm functionality and power control continuity in steady-state and dynamic operating conditions. The test sequences are sent by the RCT under program control of the automated measurement setup to enable time-aligned recording of measured responses and power requests in the test sequences.

3.20
dynamic test sequence
test cycle where the requested power levels consist of many changes