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TECHNICAL SPECIFICATION

colour inside

Sensing devices for non-intrusive load monitoring (NILM) systems

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FOREWORD

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

Draft	Report on voting
85/727/DTS	85/750/RVDTS

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 Specification 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/standardsdev/publications.

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Non-intrusive load monitoring (NILM), or non-intrusive appliance and load monitoring (NIALM), is a process for providing estimated energy usage, e.g. by type of use (heating, cooling, etc.) or type of appliance (microwave, etc.) based on load signatures at a single point in the installation.

NILM systems can be used to survey the specific uses of electrical power in homes, buildings or industrial areas (see Figure 1).

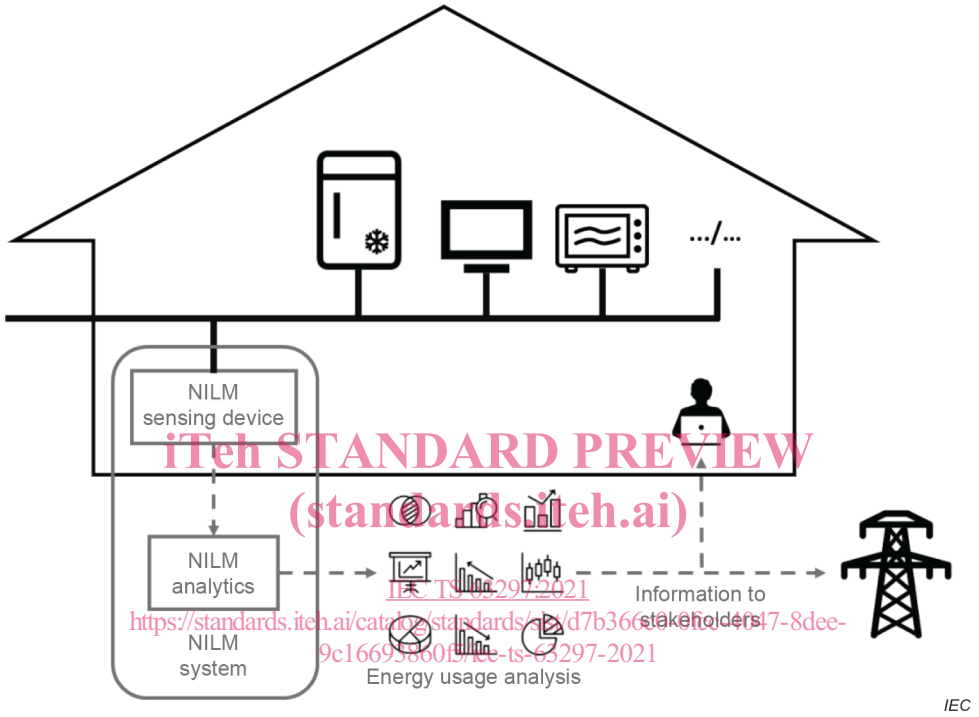

Figure 1 – Principle of non-intrusive load monitoring (NILM)

At the moment, NILM systems are essentially used in AC distribution networks, but DC networks are not excluded.

SENSING DEVICES FOR NON-INTRUSIVE LOAD MONITORING (NILM) SYSTEMS

1 Scope

This Technical Specification is an attempt to provide classification of NILM sensing devices for use in NILM systems, according to the state of the art of NILM technologies.

The classification of NILM analytics and NILM systems, as well as performance indicators for NILM systems, can be considered in the future.

NILM systems produce estimated disaggregation into energy usages. When accurate measurement and analysis of energy consumption and/or other electrical parameters is needed (e.g. for monitoring the electrical installation), systems based on standardized measuring devices (e.g. PMD, PQI or meters) are used.

NOTE Standardized measuring devices have guaranteed accuracy over a specified range and have limited deviations in presence of influence quantities (temperature, frequency deviations, etc.) in addition to safety and constructional requirements. See Annex C for more information.

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 http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
electrical parameter
electrical quantity to be measured or estimated

EXAMPLE RMS value of current, RMS value of voltage, active power, reactive power, harmonics, power quality related parameters, etc.

3.2
estimated value
value of an electrical parameter (e.g. current, power, energy related to a specific usage) produced by a NILM sensing device or a NILM system

Note 1 to entry: Estimated values are typically less accurate than values measured with standardized measuring devices (e.g. PMD, PQI, meters).

3.3
measured value
value of an electrical parameter (e.g. current, power, energy related to a specific usage) produced by a measuring device complying with an electrical measurement standard

Note 1 to entry: Examples of measuring devices complying with an electrical measurement standard include PMD, PQI and meters.

3.4
load signature
pattern in the data produced by a NILM sensing device that can be attributed to a specific type of load or energy usage

3.5
non-intrusive load monitoring
NILM
process for providing estimated categorization of energy usage based on load signatures obtained at a single point in the installation

3.6
NILM analytics
process for analysing data produced by a NILM sensing device and providing information about energy usage

Note 1 to entry: NILM analytics can be performed within the NILM sensing device and/or in the cloud.

3.7
NILM sensing device
NSD
device connected to the electrical installation and producing data to be used by NILM analytics

3.8
NILM system
combination of a NILM sensing device and NILM analytics

3.9
power metering and monitoring device
PMD
combination in one or more devices of several functional modules dedicated to metering and monitoring electrical parameters in energy distribution systems or electrical installations, used for applications such as energy efficiency, power monitoring and network performance

Note 1 to entry: Under the generic term "monitoring" are also included functions of recording, alarm management, etc.

Note 2 to entry: PMDs have a known measurement uncertainty over a specified measurement range and are robust to influence quantities and industrial environments

[SOURCE: IEC 61557-12:2018, 3.1.1, modified – Note 2 to entry has been modified and Note 3 to entry has been deleted]

3.10
power quality instrument
PQI
instrument complying with IEC 62586-1 whose main function is to measure, record and possibly monitor power quality parameters in power supply systems, and whose measuring methods (class A or class S) are defined in IEC 61000-4-30

Note 1 to entry: PQIs have a known measurement uncertainty over a specified measurement range and are robust to influence quantities and industrial environments. They often also have transient event detection and waveform capture capabilities.

[SOURCE: IEC 62586-1:2017, 3.1.1, modified – A reference to IEC 62586-1 and Note 1 to entry have been added]

3.11
gapless measurement
measurement technique where the measurement is performed continuously without gap, that is, using contiguous measurement windows

Note 1 to entry: For digital techniques and for a given sampling rate, no sample shall be missing in the measurement processing.

Note 2 to entry: When gapless measurement techniques are used, no assumption is made regarding the stability of the signal, as opposed to non-gapless measurement techniques, where the signal is considered to be stable during the time where no measurement is done.

4 Elements of a NILM system

4.1 General

A NILM system comprises (see Figure 2):

– a NILM sensing device (NSD) connected to the electrical installation and producing data relevant for load signature identification;
– NILM analytics using the data output from the NSD and producing information to the users about their energy usage.

Figure 2 – Elements of a NILM system

The performance of the NILM system depends on the characteristics of the NILM sensing device (NSD) and on the characteristics of the NILM analytics. There are a lot of differences between the NILM systems available today. For example:

- NILM systems may use several types of NSD, e.g.
  a) meter;
  b) power metering and monitoring devices (PMD);
  c) power quality instrument (PQI);
  d) dedicated proprietary hardware;
- Some NILM systems may produce energy usage information over one day, while others may show results on a much shorter time scale;
- Some NILM systems may disaggregate into types of usage, others may disaggregate into types of current using equipment (e.g. appliances), while others may focus on providing behavioural analysis.

NILM analytics may also use data produced by smart devices. Smart devices are devices producing information not related to electrical quantities, e.g. position sensors, motion sensors, temperature control equipment, etc.

4.2 NILM sensing device

A NILM sensing device (NSD) is a device connected to the electrical installation. It produces data that can be used by NILM analytics. Examples of data that may be produced by an NSD include:

- samples of current and/or voltage waveforms;
- features characterizing the current and/or voltage waveforms;
- features related to the high-frequency patterns in the electrical signals;
- estimated values of electrical parameters;
- measured values of electrical parameters.

4.3 NILM analytics

The value of NILM systems is essentially in the analytics and how well they are able to make use of the data produced by the NSD.

NILM analytics are algorithms that analyse the data output by an NSD and produce estimated disaggregated information that can help stakeholders make decisions.

Examples of information that may be produced by NILM analytics are:

- estimated disaggregation of energy consumption into specific usages (heating, refrigeration, entertainment…);
- estimated disaggregation of energy consumption into specific types of appliances (ovens, fridges, pumps…).

NOTE NILM systems produce estimated disaggregation into energy usages. When accurate measurement and analysis of energy consumption and/or other electrical parameters is needed (e.g. for monitoring the electrical installation), systems based on standardized measuring devices (e.g. PMDs or meters) are used.

5 Classification of NILM sensing devices (NSD)

5.1 General

A NILM sensing device (NSD) is a gateway between the physical electrical installation and the world of analytics. In order to operate efficiently, NILM algorithms need to know the type of data they are to process. The behaviour of the NSD depends on several characteristics (see Figure 3).

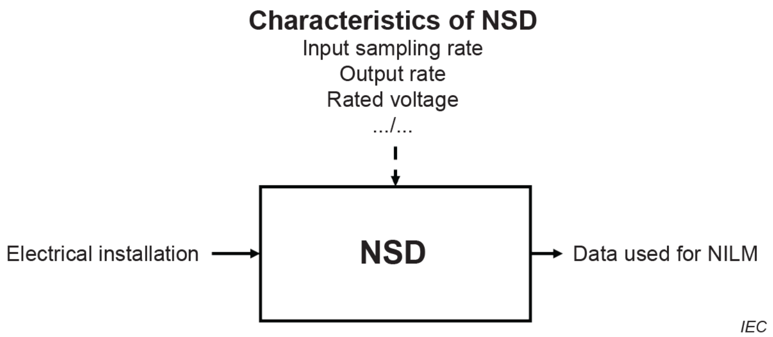

Figure 3 – Component view of a NILM sensing device (NSD)

To facilitate the development of NILM analytics, it is useful to specify the characteristics of NILM sensing devices, for easier selection and comparison.