BS EN 62779-2:2016

BSI Standards Publication

Semiconductor devices — Semiconductor interface for human body communication

Part 2: Characterization of interfacing performances

National foreword

This British Standard is the UK implementation of EN 62779-2:2016. It is identical to IEC 62779-2:2016.

The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductors.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Semiconductor devices - Semiconductor interface for human body communication - Part 2: Characterization of interfacing performances (IEC 62779-2:2016)

Dispositifs à semiconducteurs - Interface à semiconducteurs pour les communications via le corps humain - Partie 2: Caractérisation des performances d'interfaçage
(IEC 62779-2:2016)

Halbleiterbauelemente - Halbleiterschnittstelle zur Kommunikation über den menschlichen Körper - Teil 2: Beschreibung der Schnittstellenfunktion
(IEC 62779-2:2016)

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European foreword

The text of document 47/2268/FDIS, future edition 1 of IEC 62779-2, prepared by IEC/TC 47 "Semiconductor devices" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62779-2:2016.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2016-12-24
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IEC 62779	NOTE	Harmonized in EN 62779 series.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES – SEMICONDUCTOR INTERFACE FOR HUMAN BODY COMMUNICATION –

Part 2: Characterization of interfacing performances

FOREWORD

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The text of this standard is based on the following documents:

FDIS	Report on voting
47/2268/FDIS	47/2278/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62779 series, published under the general title *Semiconductor devices – Semiconductor interface for human body communication*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The IEC 62779 series is composed of three parts as follow:

- IEC 62779-1 defines general requirements of a semiconductor interface for human body communication. It includes general and functional specifications of the interface.
- IEC 62779-2 defines a measurement method on electrical performances of an electrode that constructs a semiconductor interface for human body communication.
- IEC 62779-3 defines functional type of a semiconductor interface for human body communication, and operational conditions of the interface.

SEMICONDUCTOR DEVICES – SEMICONDUCTOR INTERFACE FOR HUMAN BODY COMMUNICATION –

Part 2: Characterization of interfacing performances

1 Scope

This part of IEC 62779 defines a measurement method on electrical performances of an electrode that composes a semiconductor interface for human body communication (HBC). In the measurement method, a signal transmitter is electrically isolated from a signal receiver, so an isolation condition between the transmitter and receiver is maintained to accurately measure the electrode's performances. This part includes general and functional specifications of the measurement method.

HBC uses the body of a user as a transmission medium using near-field coupling inside the body: a signal transmitter and receiver are coupled with each other through a near field that is formed inside the human body and air. The intensity of the near field is strong especially inside the body due to high dielectric constant of the body, so a data signal is transmitted through the human body by modulating the near field. A signal transmitter and receiver for HBC include an internal ground respectively, and, in most HBC applications, the grounds are separated from each other as maintaining the coupling condition through the air. Quality of a data transmission strongly depends on a coupling degree between the grounds; hence, it is important to maintain the coupling degree between grounds of a signal transmitter and receiver for an accurate measurement of the electrode's performances. This part defines a measurement method to measure electrical performances of an electrode while the coupling degree between grounds of a signal transmitter and receiver is maintained.

NOTE 1 HBC semiconductor interface consists of an electrode and analog front end.

NOTE 2 General analog and digital modulation techniques can be used to modulate a near field used in HBC, and a modulation technique to be used is determined according to required performances for a data transmission and a HBC application.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

None.

3 Terms, definitions and letter symbols

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

3.1 General terms

3.1.1
electrode
physical structure to transmit an electrical signal between an analog front end and the human body while attached to or located near the human body

Note 1 to entry: An electrode transfers an electrical signal to be transmitted to a non-metallic transmission channel, the human body. It also transfers an electrical signal received from the human body to the analog front end.

Note 2 to entry: electrode can have an adhesive material on its surface like a disposable ECG electrode to be attached itself to the human body; or a metal surface for a simple implementation. In the case of a metal surface, an electrode makes contact with the human body by attaching it to the human body using an attachment aid like a rubber band; or simply touching it with the hand.

[SOURCE: IEC 62779-1: 3.1.1, modified – Note 2 to entry has been added.]

3.1.2

transmitter module

circuit module that generates a pulse signal to be transmitted to the human body through an electrode for measurement of the electrode's performances; and a synchronization signal of an optical type to be transmitted through an optical cable for synchronization of the pulse signal transmitted through the human body

Note 1 to entry: A transmitter module includes a signal amplifier to amplify the transmitting pulse signal; and a signal filter to remove a signal component causing an interference to other measurement modules and measurement equipment.

3.1.3

receiver module

circuit module that processes a pulse signal received from the human body through an electrode to increase signal quality for measurement of the electrode's performances

Note 1 to entry: A receiver module includes a signal amplifier to amplify the received pulse signal; and a signal filter to remove a noise or interference signal from the received pulse signal.

3.1.4

synchronization module

circuit module that transforms a synchronization signal transmitted through an optical cable into an electrical signal; and generates a trigger signal using the transformed synchronization signal to trigger measurement equipment

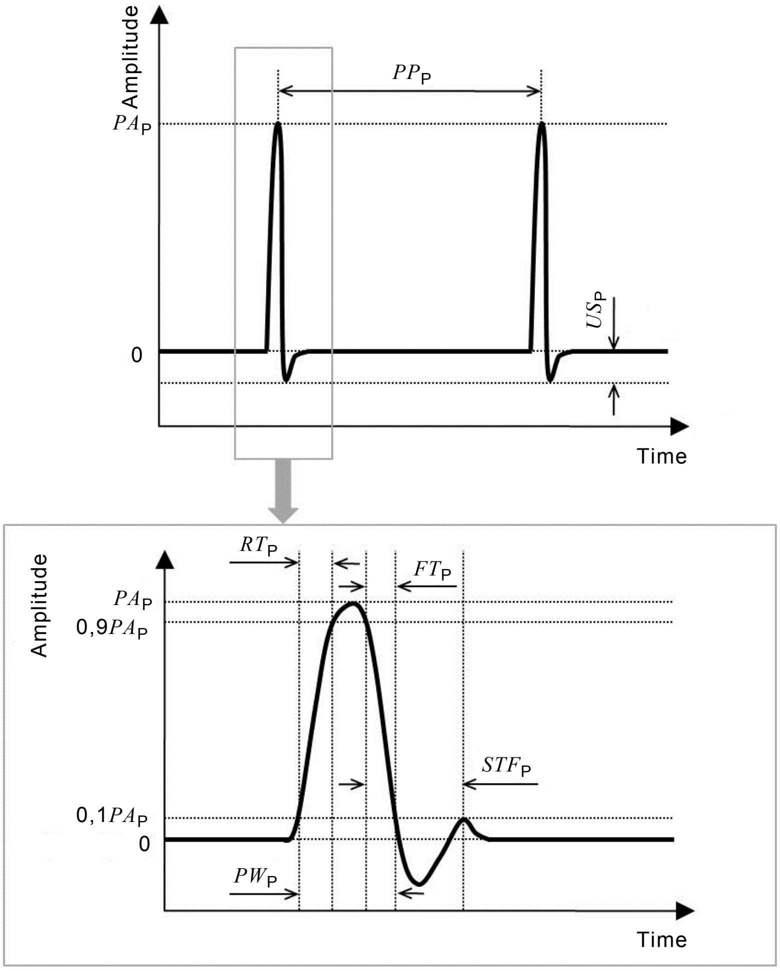
Note 1 to entry: A synchronization module includes an optical transceiver to transform an optical signal into an electrical signal or vice versa.

3.1.5

pulse signal

electrical signal that is generated in the transmitter module and then transmitted to the human body through an electrode to measure the electrode's performances while having a specific pulse-width to include a signal component at frequency bands over which the performances are to be measured

Note 1 to entry: Figure 1 shows a pulse signal and its related terms.



IEC

Key

PA_p	Pulse amplitude	PP_p	Pulse period
US_p	Undershoot	PW_p	Pulse width
RT_p	Rising time	FT_p	Falling time
STF_p	Settling time of falling		

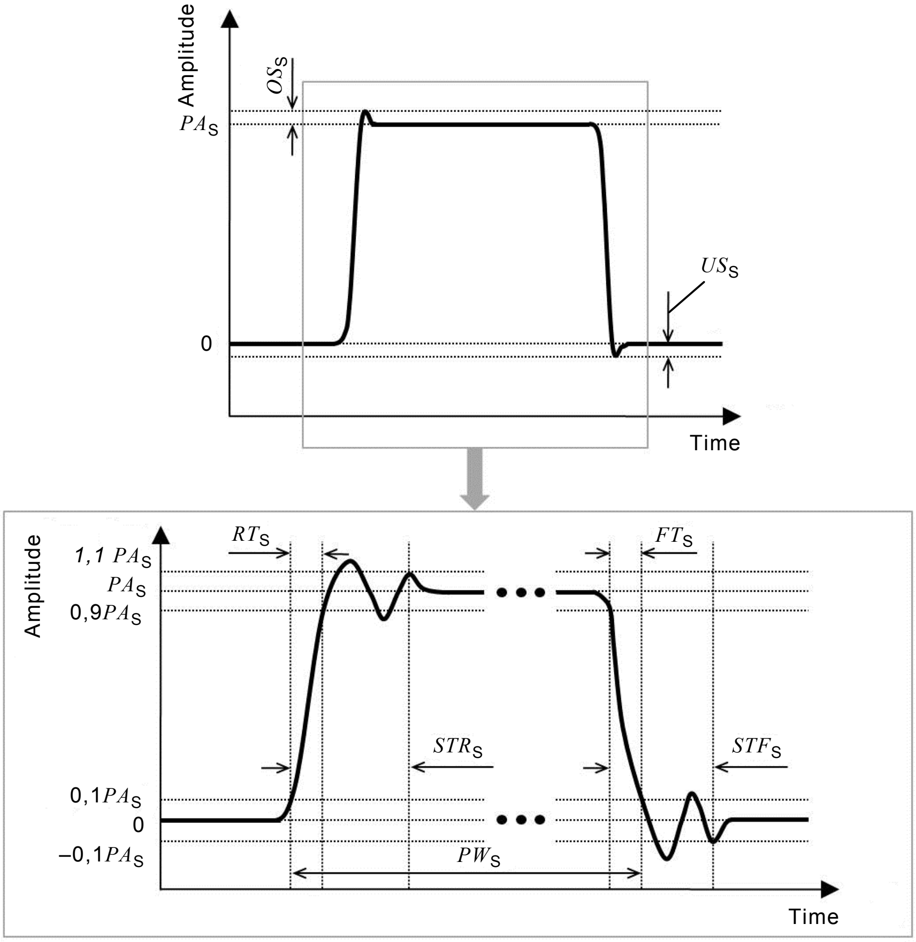
Figure 1 – Pulse signal

Note 2 to entry: A pulse signal has a short pulse-width to include a signal component at a wide-frequency band.

3.1.6
synchronization signal

electrical signal that is synchronized to the pulse signal and then transformed into an optical signal to be transmitted to a synchronization module through an optical cable for the purpose of synchronization between the transmitter and receiver modules

Note 1 to entry: Figure 2 shows a synchronization signal and its related terms.



IEC

Key

PA_s	Pulse amplitude	OS_s	overshoot
US_s	Undershoot	PW_s	Pulse width
RT_s	Rising time	FT_s	Falling time
STR_s	Settling time of rising	STF_s	Settling time of falling

Figure 2 – Synchronization signal

3.2 Signal characteristics

3.2.1

pulse amplitude

PA_p

peak amplitude of pulse signal in volts

3.2.2

pulse period

PP_p

time period of periodic pulses in seconds

3.2.3

undershoot

US_p

minimum amplitude in volts during transient period of a falling signal

3.2.4
pulse width
PW_p
time interval in seconds between points at which a pulse signal has 10 % value of pulse amplitude

3.2.5
rising time
RT_p
time interval in seconds required for a pulse signal to rise from 10 % value of pulse amplitude to 90 % value

3.2.6
falling time
FT_p
time interval in seconds required for a pulse signal to fall from 90 % value of pulse amplitude to 10 % value

3.2.7
settling time of falling
STF_p
maximum time interval in seconds required for a pulse signal to fall from 90 % value of pulse amplitude to 10 % or −10 % value during transient period of a falling signal

3.2.8
pulse amplitude
PA_s
peak amplitude of a synchronization signal in volts after transient period of a rising signal

3.2.9
overshoot
OS_s
differential amplitude in volts from pulse amplitude to peak amplitude during transient period of a rising signal

3.2.10
undershoot
US_s
minimum amplitude in volts during transient period of a falling signal

3.2.11
pulse width
PW_s
time interval in seconds between points at which a synchronization signal has 10 % value of pulse amplitude

3.2.12
rising time
RT_s
time interval in seconds required for a synchronization signal to rise from 10 % value of pulse amplitude to 90 % value

3.2.13
falling time
FT_s
time interval in seconds required for a synchronization signal to fall from 90 % value of pulse amplitude to 10 % value

3.2.14
settling time of rising

STR_s

maximum time interval in seconds required for a synchronization signal to rise from 10 % value of pulse amplitude to 110 % or 90 % value during transient period of a rising signal

3.2.15
settling time of falling

STF_s

maximum time interval in seconds required for a synchronization signal to fall from 90 % value of pulse amplitude to 10 % or −10 % value during transient period of a falling signal

3.3 Letter symbols

For the purposes of this document, the letter symbols given in Table 1 apply.

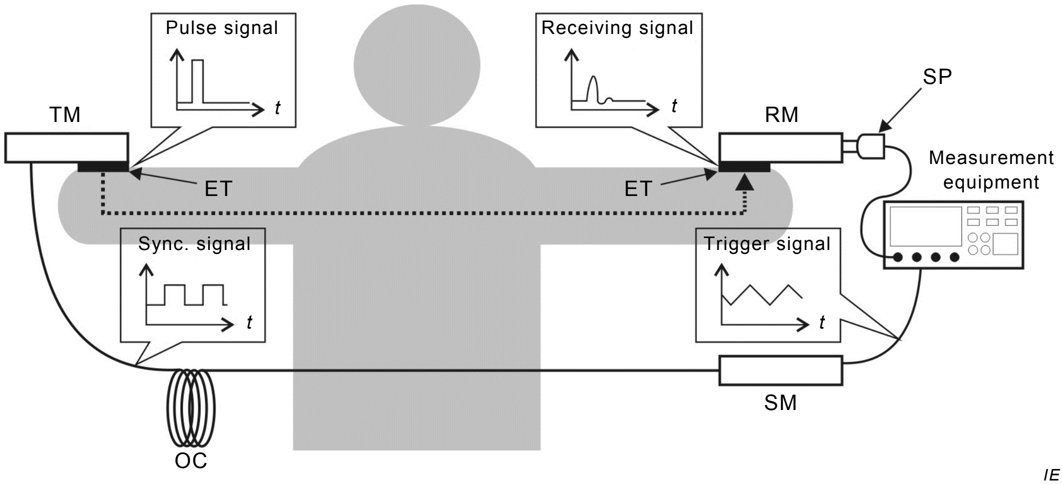
Table 1 – Letter symbols

Name and designation	Letter symbol
Pulse amplitude	PA_p
Pulse period	PP_p
Undershoot	US_p
Pulse width	PW_p
Rising time	RT_p
Falling time	FT_p
Settling time of falling	STF_p
Pulse amplitude	PA_s
Overshoot	OS_s
Undershoot	US_s
Pulse width	PW_s
Rising time	RT_s
Falling time	FT_s
Settling time of rising	STR_s
Settling time of falling	STF_s

4 Measurement of electrical performances of electrode

4.1 Measurement setup

A measurement setup as shown in Figure 3 is applied to measure interface performances while maintaining a coupling degree between grounds inside a signal transmitter and receiver.



IEC

Key

TM	Transmitter module	RM	Receiver module
SM	Synchronization module	OC	Optical cable
SP	Signal probe	ET	Electrode

Figure 3 – Measurement setup

4.2 Measurement apparatus and signal specifications

4.2.1 Transmitter and receiver module

4.2.1.1 General

For an accurate measurement of the electrode's performances, physical and electrical specifications of the modules are determined as follows.

4.2.1.2 Size of internal ground plane

An internal ground plane inside a transmitter and receiver module shall have the same size as that of a device to which a HBC semiconductor interface is applied.

4.2.1.3 Amplitude of pulse signal

A pulse signal transmitted through an electrode to the human body shall have enough small amplitude to minimize any potential harmful health effects that may occur during transmitting the pulse signal.

If applicable, general regulations to limit human exposure to electromagnetic fields (EMF) shall be satisfied.

4.2.1.4 Interface

Each module shall include an interface for a measurement equipment to measure a pulse signal in the transmitter module and a processed signal in the receiver module.

4.2.1.5 Modulation technique

In the transmitter, any modulation technique can be used to transform a synchronization signal to an optical signal transmitted through an optical cable.

4.2.2 Synchronization module

4.2.2.1 General

A synchronization module shall be sufficiently distant from the human body to avoid signal interference with a pulse signal transmitted through the human body.

4.2.2.2 Demodulation technique

A demodulation technique corresponding to the modulation technique used for a synchronization signal shall be used to transform an optical signal received through an optical cable to a synchronization signal.

4.2.3 Measurement equipment

Measurement equipment including a signal probe shall be prepared to measure a pulse signal in the transmitter module and a processed signal in the receiver module respectively.

The measurement equipment shall be synchronized with the pulse signal in transmitter using a trigger signal generated from the synchronization module.

4.2.4 Signal specifications

4.2.4.1 General

The following specifications of the signals that are used for measurement shall be given.

4.2.4.2 Pulse signal

The following specifications of the pulse signal shall be given:

a) pulse amplitude;
b) pulse period;
c) undershoot;
d) pulse width;
e) rising time;
f) falling time;
g) settling time of falling.

4.2.4.3 Synchronization signal

The following specifications of the synchronization signal shall be given:

a) pulse amplitude;
b) overshoot;
c) undershoot;
d) pulse width;
e) rising time;
f) falling time;
g) settling time of rising;
h) settling time of falling.

4.3 Measurement procedure

4.3.1 General

The interface performance is measured according to the following procedure.

4.3.2 Attachment of transmitter and receiver modules

A transmitter and a receiver module, each having an electrode under measurement, are attached to the human body.

4.3.3 Transmission of pulse and synchronization signals

A pulse signal that is generated in a transmitter module is transmitted to the human body through the electrode. Furthermore, a synchronization signal that is synchronized to the pulse signal is transmitted to an optical cable for synchronization after being transformed into an optical signal.

4.3.4 Synchronization of measurement equipment

A synchronization module transforms an optical signal transmitted through an optical cable into a synchronization signal; it then generates a trigger signal to synchronize a measurement equipment to a pulse signal in a transmitter module.

4.3.5 Signal processing in receiver module

A receiving signal is processed in a receiver module. The signal processing includes signal amplification and filtering.

4.3.6 Measurement of pulse and processed signal

A pulse signal in a transmitter module is measured using a signal probe in the measurement equipment; then a processed signal in a receiver module is measured using the same signal probe while synchronization with a pulse signal in a transmitter module is maintained.

4.3.7 Compensation for signal processing

An amplitude gain by signal processing in a receiver module is compensated to obtain a receiving signal received at an electrode of the receiver module.

4.3.8 Computation of impulse response and complex transfer function

After pulse and receiving signals are respectively transformed into the frequency domain, the transformed receiving signal is subtracted from the transformed pulse signal to obtain a complex transfer function. An impulse response is obtained by transforming the obtained complex transfer function into the time domain.

4.4 Post processing for electrode performances

4.4.1 General

After obtaining an impulse response, $h[n]$, and complex transfer function, $H[m]$, from the comparison of the pulse and receiving signals, electrical performances shall be calculated as follows.

4.4.2 In-band average signal-loss

The in-band average signal-loss can be calculated from the complex transfer function as follows:

$$SL_{\text{average}} = \frac{1}{M_1 - M_2 + 1} \sum_{m=M_1}^{M_2} \left| H[m] \right| \tag{1}$$

Here, SL_{average} is the in-band average signal loss, and $H[m]$ is the complex transfer function with a frequency index m. M_1 and M_2 represent the frequency band where the signal loss is averaged.

4.4.3 In-band average phase-shift

The in-band average phase-shift can be calculated from the complex transfer function as follows:

$$PS_{\text{average}} = \frac{1}{M_1 - M_2 + 1} \sum_{m=M_1}^{M_2} \angle \left| H[m] \right| \tag{2}$$

Here, PS_{average} is the in-band average phase-shift.

4.4.4 RMS delay

The RMS delay can be calculated from a power delay profile defined as follows:

$$P(n) = \frac{\left| h[n] \right|^2}{\sum_{n=N_1}^{N_2} \left| h[n] \right|^2} \tag{3}$$

Here, $P(n)$ is the power delay profile and $h[n]$ is the impulse response. N_1 and N_2 are a time index to represent the time interval where the impulse response is obtained. The RMS delay, the second central moment, is expressed as:

$$\tau_{\text{RMS}} = t_{\text{s}} \cdot \left[\sum_{\tau=N_1}^{N_2} (\tau - \tau_e)^2 \cdot P(\tau) \right]^{\frac{1}{2}} \tag{4}$$

Here, τ_{RMS} is the RMS delay, and t_{s} is the sampling interval. τ_{e} is the first moment of the power delay profile defined as:

$$\tau_e = t_s \cdot \sum_{\tau=N_1}^{N_2} \tau \cdot P(\tau) \tag{5}$$

4.4.5 Coherent bandwidth

The coherence bandwidth is a measure of the frequency range over which a frequency correlation function can be considered flat. The frequency correlation function is defined using the complex transfer function as follows:

$$R(\Delta m) = \sum_{m=-\infty}^{\infty} H[m] \cdot H^*[m + \Delta m] \tag{6}$$

Here, $R(\Delta m)$ is the coherent bandwidth. Also, $H^*[m+\Delta m]$ is the complex conjugate of $H[m+\Delta m]$. The coherence bandwidth is defined usually as the frequency shift at which the frequency correlation function has a value corresponding to 90 % of its peak value.

Bibliography

IEC 62779 (all parts), *Semiconductor devices – Semiconductor interface for human body communication*

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