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Semiconductor devices — Semiconductor interface for human body communication

Part 1: General requirements

bsi.

National foreword

This British Standard is the UK implementation of EN 62779-1:2016. It is identical to IEC 62779-1:2016.

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European foreword

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CONTENTS

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SEMICONDUCTOR DEVICES – SEMICONDUCTOR INTERFACE FOR HUMAN BODY COMMUNICATION –

Part 1: General requirements

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

FDIS	Report on voting
47/2267/FDIS	47/2277/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.

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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 [1] defines functional type of a semiconductor interface for human body communication, and operational conditions of the interface.

IEC 60748-4 gives requirements on interface integrated circuits for semiconductor devices. Especially, Chapter III, Section 7 in this standard is applied to interface circuits for a communication network using a general channel, such as wire or wireless. However, a channel for HBC is the human body whose channel properties, such as signal loss and delay profile, are different from the general channel, so Chapter III, Section 7 can't be applied to an interface for HBC. Furthermore, a standard on a communication protocol for body area network (BAN) – IEEE 802.15.6, which includes a communication protocol for HBC was published in 2012. A common interface for HBC should be defined to secure communication compatibility between various devices that are implemented on/inside the human body or embedded in peripheral equipments.

1 To be published.

SEMICONDUCTOR DEVICES – SEMICONDUCTOR INTERFACE FOR HUMAN BODY COMMUNICATION –

Part 1: General requirements

1 Scope

This part of IEC 62779 defines general requirements for a semiconductor interface used in human body communication (HBC). It includes general and functional specifications of the interface, as well as limiting values and its operating conditions.

NOTE Additional information on HBC is provided in Annex A.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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
HBC semiconductor interface
semiconductor interface to process an electrical signal that is transmitted to the human body or received from the human body while located between the human body and HBC modem; implemented on/inside the human body and embedded in peripheral equipment

Note 1 to entry: HBC semiconductor interface consists of an electrode and analog front end. The HBC modem converts data into an electrical signal and sends it to the electrode, or receives an electrical signal from the analog front end and converts it into data.

Note 2 to entry: This note applies to the French language only.

3.1.2
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.

3.1.3
analog front end
semiconductor integrated circuit to recover original data from a receiving signal transmitted through the human body

Note 1 to entry: Analog front end includes a powerline noise reduction filter, a signal amplifier, a high-pass filter, a comparator and a clock and data recovery (CDR) circuit to recover original data transmitted through a non-metallic transmission channel. Also, it generates control signals to control operations of each component in the analog front end.

3.1.4
powerline noise reduction filter
circuit component in an analog front end to remove a powerline noise signal included in a receiving signal by an antenna function of the human body

Note 1 to entry: Additional information on generation of a powerline noise signal is provided in Annex B.

3.1.5
comparator
circuit component in an analog front end to compare two signals and switch its output signal to indicate which is larger

3.1.6
CDR circuit
circuit component in an analog front end to generate a clock from a receiving signal and align phase of the receiving signal to the generated clock

3.2 Rating and characteristics

3.2.1 Input characteristics

3.2.1.1
supply voltage
V_S
supply voltage to operate a HBC semiconductor interface

3.2.1.2
normal mode supply current
I_S
total supply current during normal mode of a HBC semiconductor interface

3.2.1.3
disabled mode supply current
$I_{DISABLED}$
total supply current during disabled mode of a HBC semiconductor interface

3.2.1.4
input impedance
Z_I
impedance seen by the human body into a HBC semiconductor interface

Note 1 to entry: Input impedance depends on input impedances of a powerline noise reduction filter, signal amplifier and high-pass filter.

Note 2 to entry: A powerline noise reduction filter removes a high-power noise signal which can saturate the active components in the interface.

3.2.2 Transfer characteristics

3.2.2.1
sensitivity level
SL
signal's minimum voltage at an input of a HBC semiconductor interface that is required to produce a signal having a specified signal-to-noise ratio at an output

Note 1 to entry: Additional information on the sensitivity level is provided in Annex C.

Note 2 to entry: This note applies to the French language only.

3.2.2.2
dynamic range
DR
ratio of a signal's maximum voltage at an input of a HBC semiconductor interface that can be tolerated without signal distortion to a minimum that is required to have a specific signal-to-noise ratio at an output

Note 1 to entry: Dynamic range depends on a minimum drive level of a comparator and a signal gain of a signal amplifier. Additional information on the sensitivity level is provided in Annex C.

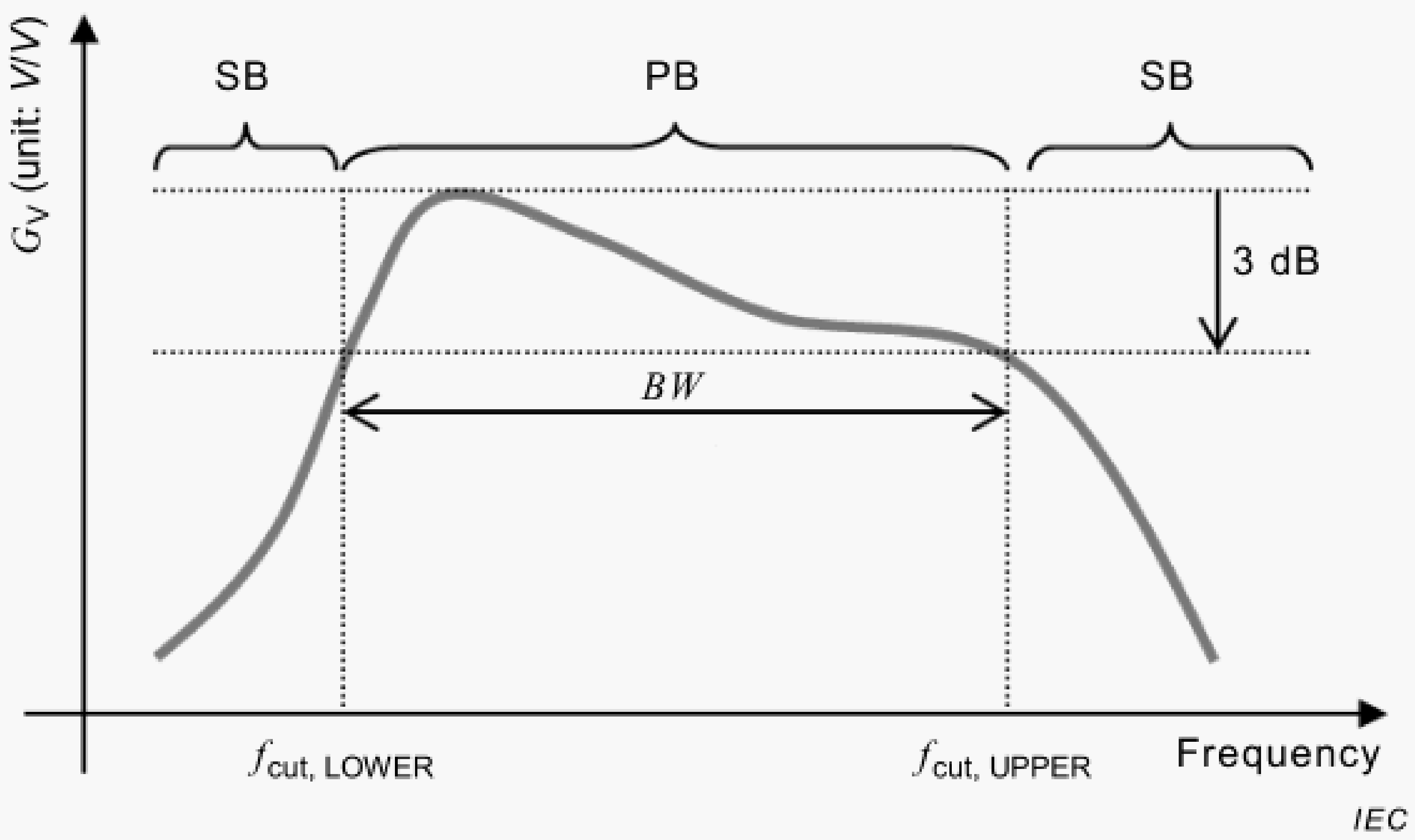
Note 2 to entry: This note applies to the French language only.

3.2.2.3
voltage gain
G_V
increasing amount of a signal's voltage that is gained as passing through a signal amplifier and a high-pass filter without being attenuated or removed intentionally

3.2.2.4
lower cut-off frequency
$f_{CUT,LOWER}$
lower frequency where a receiving signal is attenuated by 3 dB as passing through a high-pass filter

3.2.2.5
upper cut-off frequency
$f_{CUT,UPPER}$
upper frequency where a receiving signal is attenuated by 3 dB as passing through a high-pass filter

3.2.2.6
bandwidth
BW
frequency range width over which signals having corresponding frequencies pass through a signal amplifier and a high-pass filter without being attenuated or removed intentionally (see Figure 1)



Key

G_v	Voltage Gain	SB	Stop Band
PB	Pass Band	*BW*	Bandwidth
$f_{cut.LOWER}$	Upper Cut-off Frequency	$f_{cut.UPPER}$	Lower Cut-off Frequency

Figure 1 – Definition of cut-off frequency and bandwidth

Note 1 to entry: This note applies to the French language only.

3.2.2.7
lock range
LR
frequency range's width over which the CDR circuit can be locked

Note 1 to entry: This note applies to the French language only.

3.3 Letter symbols

All the letter symbols related to input and transfer characteristics are summarized in Table 1 below.

Table 1 – Letter symbols

Name and designation	Letter symbol
supply voltage	V_S
normal mode supply current	I_S
disabled mode supply current	$I_{DISABLED}$
input impedance	Z_I
sensitivity level	SL
dynamic range	DR
voltage gain	G_V
lower cut-off frequency	$f_{CUT,LOWER}$
upper cut-off frequency	$f_{CUT,UPPER}$
bandwidth	BW
lock range	LR

4 General requirements for HBC semiconductor interface

4.1 General specifications

4.1.1 General

General specifications to specify functional and external requirements for HBC semiconductor interface shall be given.

4.1.2 Function

4.1.2.1 Category

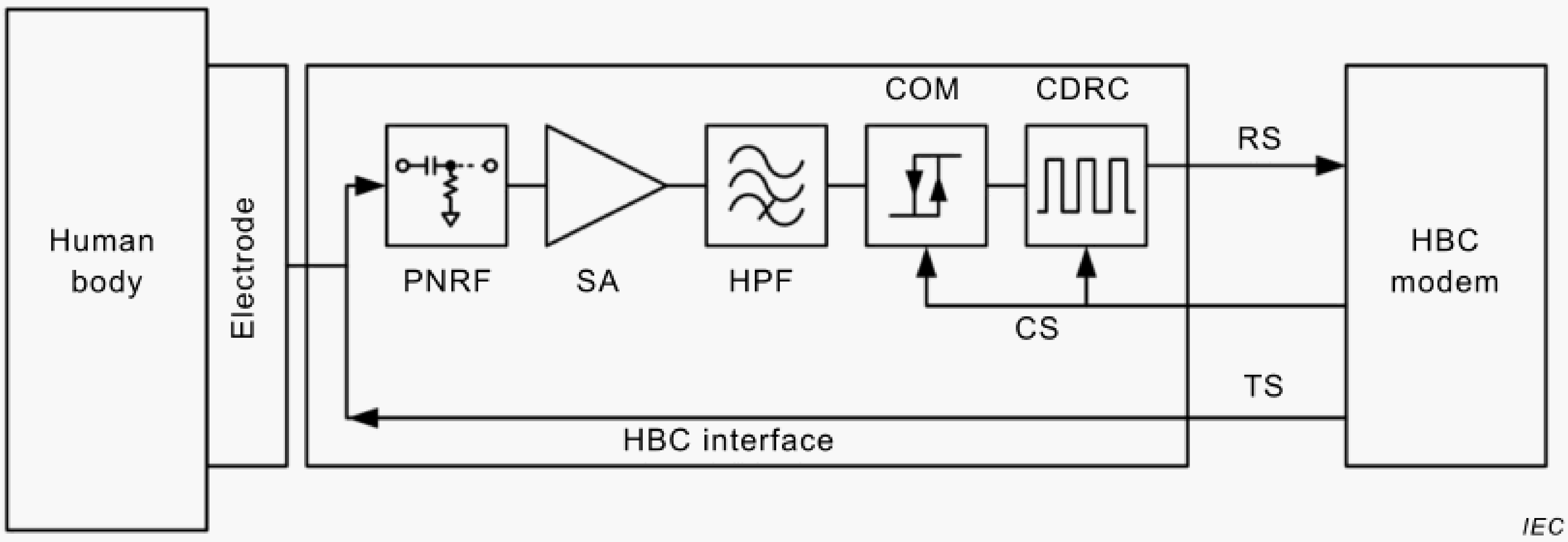
If an interface has a functional or electrical category, it shall be stated.

4.1.2.2 Functional description

A general description of the function performed by the interface shall be given.

4.1.2.3 Block diagram

The overall structure of the interface to realize the function shall be given. Details of the structure shall be given using a block diagram (see example in Figure 2).



Key

PNRF	Powerline Noise Reduction Filter	SA	Signal Amplifier
HPF	High Pass Filter	COM	Comparator
CDRC	Clock and Data Recovery Circuit	CS	Control Signal
RS	Receiving Signal	TS	Transmitting Signal

NOTE 1 The powerline noise reduction filter can be removed if the noise signal does not have enough high power to saturate the active components in the interface.

NOTE 2 The order of the components in the interface can be changed if necessary, as long as the interface satisfies the required performances.

Figure 2 – Block diagram (example)

If applicable, control signals that are transmitted between the interface and a HBC modem shall be defined in the block diagram.

4.1.3 Implementation types

4.1.3.1 Manufacturing and assembling technology

The manufacturing technologies for an electrode, for example metallic pattern, thin film, etc., and an analog front end, for example semiconductor monolithic integrated circuit, thin-film integrated circuit, hybrid integrated circuit, module, etc, shall be stated. Details of the semiconductor technologies shall be included.

An assembling technology between an electrode and an analog front end, for example modularization, integration, shall be stated.

4.1.3.2 Package technology

The package type, for example ceramic, plastic or glass, shall be given.

If applicable, the IEC and/or national reference number of the outline drawing shall be stated.

4.2 Constructional specifications

The physical specifications of an electrode, for example material, dimensions, location, shall be given.

4.3 Electrical specifications

4.3.1 General

The electrical specifications should be given over the specified range of an operating temperature.

4.3.2 Power supply characteristics

The following characteristics shall be given.

a) supply voltage;
b) normal mode supply current;
c) disabled mode supply current.

4.3.3 Power supply type

A type of power supply, for example an outlet or battery, shall be given.

4.3.4 Dynamic characteristics of analog front end

4.3.4.1 Powerline noise reduction filter, signal amplifier and high-pass filter

The following characteristics shall be given with respect to the corresponding component in a powerline noise reduction filter, signal amplifier and high-pass filter.

a) input impedance at a powerline noise reduction filter;
b) sensitivity level;
c) dynamic range;
d) maximum voltage gain over a pass band;
e) minimum voltage gain over a pass band;
f) decrease rate of voltage gain over a stop band;
g) bandwidth;
h) cut-off frequency.

NOTE The powerline noise reduction filter removes a high-power noise signal which can saturate the active components in the interface. The noise signal has the highest power usually at a powerline frequency, but if it has the highest power at a different frequency, the noise reduction filter is replaced with the one able to remove the corresponding noise signal.

4.3.4.2 Comparator and CDR circuit

The following characteristics shall be given with respect to the corresponding component in a comparator and CDR circuit.

a) minimum input voltage;
b) hysteresis voltage;
c) switching threshold voltage;
d) lock range.

4.3.5 CDR circuit interface

The specifications for the input signal of a CDR circuit, for example a line code type and logic level, shall be given.

4.3.6 Modem interface

4.3.6.1 Data

The specifications for a data signal that are exchanged between a HBC modem and an interface shall be given.

4.3.6.2 Clock

The specifications for a clock signal used for synchronization shall be given.

4.3.6.3 Enabling signal

The specifications for an enabling signal to enable a HBC interface shall be given.

4.3.7 Limiting values

4.3.7.1 Details to be stated

– Any dependency between the limiting values shall be specified.
– If externally connected and/or attached elements have an influence on the limiting values, the elements and their conditions shall be specified.
– If the limiting values are exceeded for transient overload, the permissible excesses and their durations shall be specified.
– All voltages are referenced to a specific reference terminal.
– The limiting values given shall cover an interface's operation over the specified range of operating temperature. If the limiting values are dependent on temperature, the dependency shall be given.

4.3.7.2 Electrical limiting values

Limiting values of the following items shall be given:

a) supply voltage;
b) supply current – normal mode;
c) supply power;
d) input voltage at an electrode.

4.3.8 Temperatures

The following temperatures shall be given:

a) operating temperature;
b) storage temperature.

4.4 Operating specifications

4.4.1 Application

4.4.1.1 Main application

The main application shall be stated, for example file transfer, real-time audio streaming and video download.

If there is any restriction in applications, it shall be stated.

4.4.1.2 Compatibility

A communication standard, for example IEEE 802.15.6 standard, that is compatible to this interface standard shall be stated. Details of the standard including its communication protocol shall be given.

4.4.2 Grounding condition

A grounding condition of an interface, for example earth or floating grounding, shall be given.

4.4.3 Contact condition

A contact condition for an electrode, for example contact or non-contact (proximity), shall be given.

Annex A
(informative)

General description of HBC

In human body communication (HBC), the body of a user is used to transmit data from one device to another, and devices can thereby communicate without a wire or wireless technology. An electrical signal including data is transmitted through the body, so the user simply touches the devices, and then the devices are connected to each other via touch-and-play (TAP) technology as shown in Figure A.1.

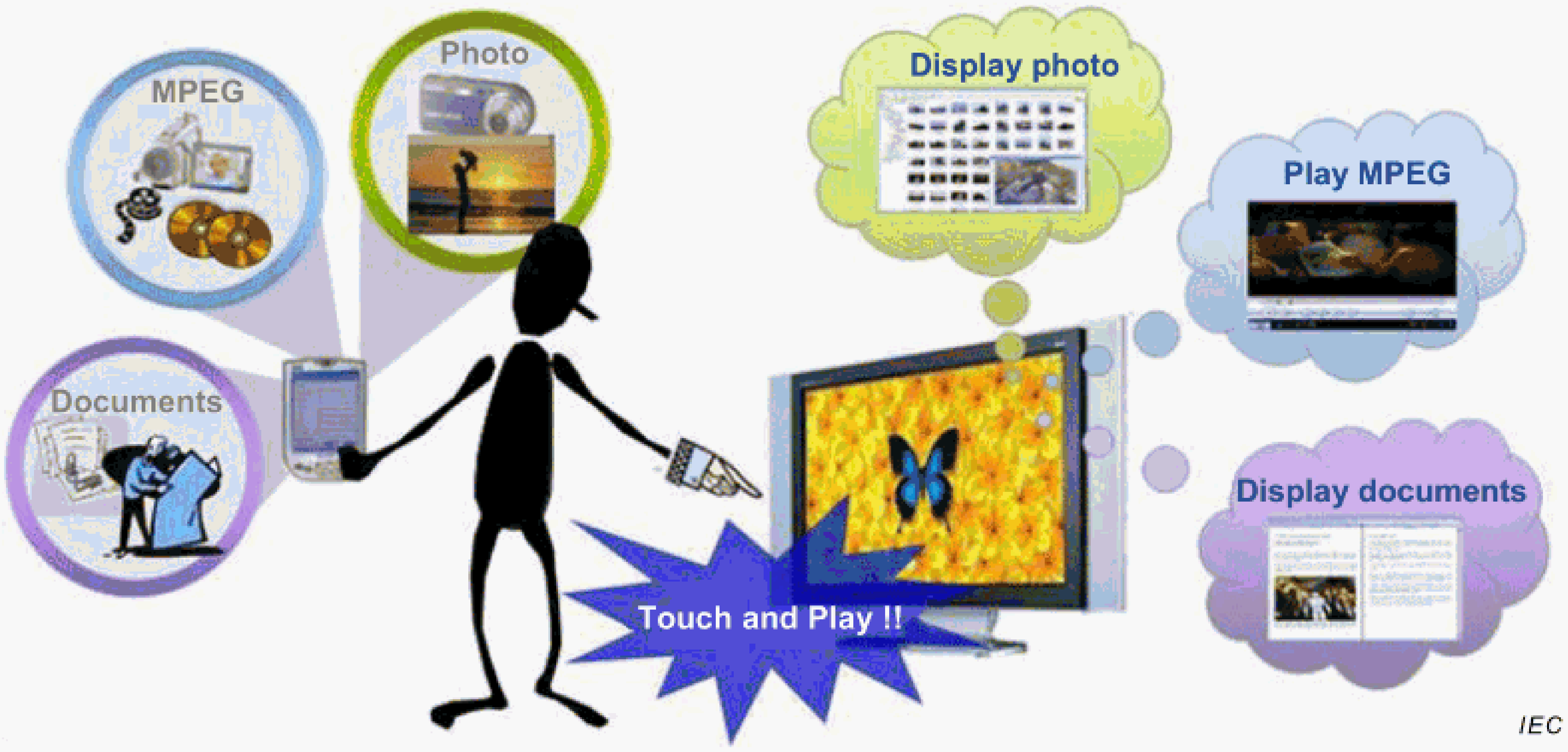


Figure A.1 – HBC applications

HBC technology is very suitable for providing a context awareness service based on TAP. After devices are connected by touch, identification signals are transmitted through the user's body, so that the type of the devices is recognized by each other. A service to be provided for the pair of the devices is determined according to the predefined context table, and then the determined service is provided while data is transmitted through the user's body. Various services which can be provided for other pairs of the devices are defined in the context table, so that a corresponding service between recognized devices can be automatically provided without the user's intervention. For example, when a user touches an advertisement device with one hand while holding a PDA in the other hand, the touch is detected by the advertisement device and the device sends information about the advertisement through the user's body, so the information can be downloaded into the PDA. Data communication between multiple devices, such as body sensor network, is also possible using HBC technology while those devices are being in contact with body. One of the devices defined as the master device controls data transmission between other devices defined as slave devices, so the user's body can be shared by the multiple devices for the data communication.

A HBC interface is defined as the connection part that inputs a data signal to the human body or outputs from the human body, while being located between a device and the human body. An electrical signal including data passes through the HBC interface from the user's device to the human body, or vice versa. The HBC interface is composed of two parts: an electrode and an analog front end. The electrode is a small piece of metal or other substance that is used to transmit the electrical signal to the human body or to receive it from the human body, while being in contact with the human body. The electrical signal transmitted to the human body is attenuated and distorted as passing through the human body. The analog front end is the circuit that restores the transmitted electrical signal from the attenuated and distorted signal. The structure of the HBC interface varies according to the HBC application. In addition, it can be implemented in a separable type with the user's device or an embedded type inside the device.

Annex B
(informative)

Generation of powerline noise signal in HBC

Electrical systems surrounding the human body radiate noise signals in the form of electromagnetic fields (EMFs), and the electromagnetic fields are coupled with the human body as shown in Figure B.1, so the noise signals are induced in the received electrical signal by HBC. It has been generally accepted that a noise signal from a powerline has the largest signal power among the noise signals, so a powerline noise reduction filter is required to maintain a permissible signal-to-noise ratio in a HBC semiconductor interface.

A powerline noise signal usually has a very high signal level, so the powerline noise reduction filter is comprised of passive components, such as lumped resistors or capacitors, to avoid saturated operation of the filter. Also, the noise reduction filter is located between the electrode and the signal amplifier to prevent saturated operation of other circuit components.

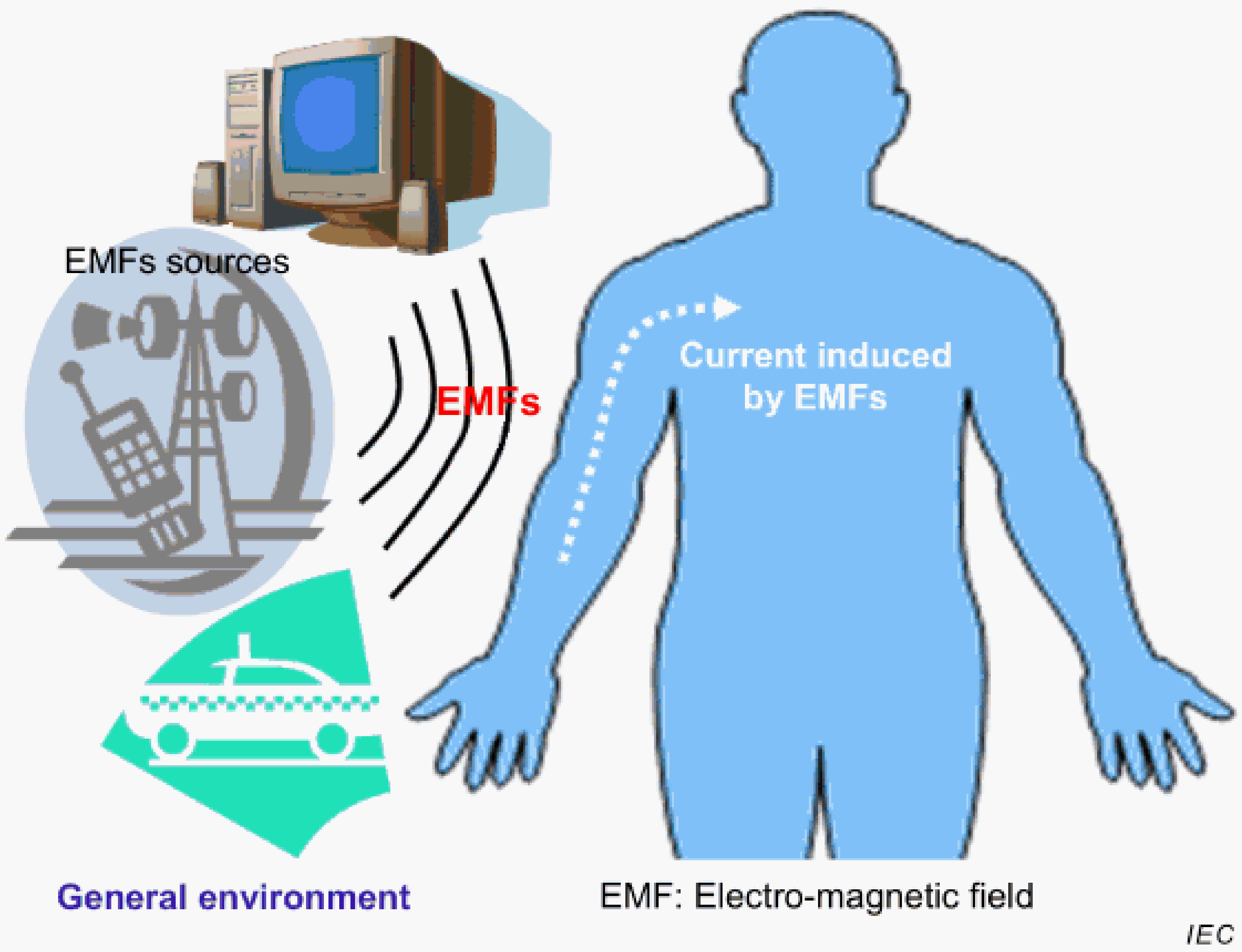


Figure B.1 – Coupling of electromagnetic fields and the human body

Annex C
(informative)

Calculation of sensitivity level

The sensitivity level depends on the minimum drive level of a comparator and the signal gain of a signal amplifier as follows.

$$V_{\text{sensitivity}} = V_{\text{min. drive level}} - G \tag{C.1}$$

Here, $V_{\text{sensitivity}}$ is the sensitivity level of a HBC semiconductor interface in dB and $V_{\text{min. drive level}}$ is the minimum input drive level of the comparator in dB. Also, G is the signal gain of the signal amplifier in dB.

The sensitivity level should be designed to satisfy Formula (C.2).

$$V_{\text{sensitivity}} > L_{\text{body, max}} + V_{\text{transmitting}} \tag{C.2}$$

Here, $L_{\text{body, max}}$ is the maximum signal loss of the human body in dB and $V_{\text{transmitting}}$ is the signal level of transmitting data in dB.

From the required sensitivity level of Formula (C.1), the signal gain of the signal amplifier and the minimum input drive level of the comparator should be designed to satisfy Formula (C.1).

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IEC 60748-4:1997, *Semiconductor devices – Integrated circuits – Part 4: Interface integrated circuits*

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

IEEE 802.15.6:2012, *Standard for Local and Metropolitan area networks – Part 15.6: Wireless Body Area Networks*

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