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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Interface for loudspeakers with digital input signals based on IEC 60958

Interface pour haut-parleurs avec signaux d'entrée numériques basés sur la CEI 60958

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERFACE FOR LOUDSPEAKERS WITH DIGITAL INPUT SIGNALS BASED ON IEC 60958

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

CDV	Report on voting
100/1433/CDV	100/1700/RVC

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

The French version of this standard has not been voted upon.

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

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- withdrawn,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 60958 interface allows transmission of 2-channel digital audio with up to 24 bit word length at 192 kHz sampling rate. This is adequate for loudspeakers, however, there are additional needs in practice that require standardisation, which go beyond what is currently defined in IEC 60958. This standard is aimed at fulfilling those needs.

IEC 60958 features a user bit that can form the basis of a control data channel that addresses those additional requirements. The format of this user bit data channel is based on the existing MIDI standard.

Beyond the needs given in IEC 60958, the following offers an exemplary, but incomplete list of of what a digital loudspeaker interface should support:

- Remote control of operating parameters of the loudspeaker.
- Remote power-on of the loudspeaker – preferably without requiring standby power in the loudspeaker.
- Remote configuration of loudspeaker, for example crossover configuration, or firmware update.
- Remote supervision of loudspeakers, for example chassis temperature or amplifier integrity.
- Remote identification of loudspeakers, to allow auto-configuration of the entire system.
- Control of individual or groups of loudspeakers through a single interface.
- Remote control of Audio System through remote control receiver mounted in loudspeaker enclosure (allowing Audio System to be placed out of sight).
- Extensions to allow for future applications.

NOTE 1 Level and mute control in the loudspeaker is preferred over digital attenuation by the signal source, as this allows the full audio data word length for the filter network; level should be controlled at the last stage in front of power amplifiers. In this case, the advantage is that the full audio word length of the given format is available at any time and at any volume setting. Especially, if a fully digitally constructed crossover network has been implemented, more precise arithmetical operations can also be made at low volumes. Volume control can thus be carried out after the crossover network or even after the relevant final amplifier. Even under the most unfavourable conditions (digital pre-attenuation and analogue gain) the filters and controllers receive the full audio word width under all operating conditions (ideal state).

NOTE 2 Not all of the listed features are required in all applications. It should therefore be up to the implementer to select from this standard the parts that are required in his application, and omit the unnecessary features. See Annex D for application examples.

INTERFACE FOR LOUDSPEAKERS WITH DIGITAL INPUT SIGNALS BASED ON IEC 60958

1 Scope

This International Standard specifies the requirements for a digital loudspeaker interface based on the IEC 60958 series of standards and the MIDI specification. It maximizes flexibility and value by combining these previously separate standards. Together, the two standards provide a simple and flexible digital interface for loudspeakers.

Examples for applications of the interface can be found in Annex C of this standard.

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.

IEC 60958 (all parts), *Digital audio interface*

IEC 60958-4, *Digital audio interface – Part 4: Professional applications*

The Complete MIDI 1.0 Detailed Specification v96.1:2001, (Second edition)

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
digitally interfaced loudspeaker
device that combines a loudspeaker with an amplifier, where the amplifier has a digital audio input port

NOTE The amplifier and loudspeaker may share a common enclosure, or they may occupy separate enclosures. The connection between amplifier and loudspeaker and the operating principle of the transducer are left unspecified and may be analogue. In the context of this standard, the term may be abbreviated as loudspeaker or speaker when there is no risk of confusion.

3.1.2
phantom power
scheme of transmitting electrical power from a source device to a target device using the balanced wiring employed for data transfer; in particular, the power is applied between both balanced signal wires and the ground or shield connection

3.1.3
audio data
data sent to the loudspeaker that is rendered as sound by the loudspeaker

NOTE Typically this data would be in PCM 2's complement format.

3.1.4
control data
data sent to the loudspeaker that controls its operating parameters

3.1.5
controller
source device for control data

3.1.6
solid state relay
assembly of an optically controlled power switch and a LED

3.2 Abbreviations

AES	Audio Engineering Society
ASIC	Application Specific Integrated Circuit
CODEC	Coder / Decoder
CPLD	Complex Programmable Logic Device
CRC	Cyclic Redundancy Check
DSP	Digital Signal Processor
FPGA	Field Programmable Gate Array
LED	Light Emitting Diode
LSB	Least Significant Bit
MIDI	Musical Instrument Digital Interface
MSB	Most Significant Bit
MSC	MIDI Show Control
MTC	MIDI Time Code
NRPN	Non Registered Parameter Number
PCM	Pulse Code Modulation
Sysex	System-exclusive

4 General

4.1 Feature set

A digitally interfaced loudspeaker conforming to this standard shall implement the following.

- A control data channel from the controller to the loudspeaker which supports transmission of MIDI messages. This may be implemented using the U-bit embedded in the IEC 60958-4 protocol as described in Clause 5.
- A command set as described in Clause 6. A basic command set is mandatory, with optional commands and manufacturer extensions being supported at the manufacturer's discretion.
- Optional: Power transmission from a controller to the loudspeaker, in order to activate the loudspeaker's power switch. It is sufficient to transmit the power to operate a LED. The power switch in the loudspeaker may be implemented with a solid state relay. A phantom supply scheme is used, which employs the balanced interface wiring defined in IEC 60958-4, see 7.1.
- Optional: A backwards data channel from the loudspeaker to the controller. As this runs opposite to the signal flow on the IEC 60958 interface, it is implemented as a data channel riding on the phantom power mentioned above, see 7.2.

4.2 Audio formats

As a configuration setting, the loudspeaker may select from the two subchannels. A mono loudspeaker shall use the left channel audio data by default, but may optionally be configured to use the right channel audio data in a manufacturer defined way.

NOTE 1 An optional parameter specifies panning between left and right channels. Speakers that implement this feature can render an arbitrary mix of the two subchannels.

It is the manufacturer's decision which audio sampling frequencies to support, and whether single channel double sampling frequency mode is supported. It is highly recommended that 48 kHz two-channel mode with no emphasis be amongst the supported formats.

NOTE 2 The manufacturer should document clearly which formats are supported.

5 Control data channel using the U-bit of IEC 60958-4

5.1 General

In the IEC 60958 interface there is a U-bit for each of the two subchannels, these form two separate control data channels with a capacity of one bit per sample each.

NOTE Using both together to form a single data channel with twice the capacity would be possible but unwise in the presence of signal routers, hence the two U-bit channels are kept separate, except when single channel double frequency mode is used.

5.2 Formatting

The U-channel shall carry data formatted according to the MIDI standard, with the bits being transmitted in inverted state. That is, a MIDI 1-bit is transmitted as a zero U-bit, and a MIDI 0-bit is transmitted as a one U-bit. This inversion ensures that an unused U-channel (which carries 0-bits by default) is interpreted by the receiver as an idle line. For each information byte, 10 bits are transmitted in the usual asynchronous frame format. The 8 data bits of a byte are framed by a start bit and a stop bit.

NOTE 1 This allows the receiver to detect the start of each byte, and it also allows the transmitter to insert an arbitrary number of idle bits between each data byte to adjust the bandwidth used.

NOTE 2 If the bits were transmitted in the non-inverted state, an idle U-channel would be seen by the MIDI receiver as a line with a continuous break condition, which is a sequence of framing errors.

NOTE 3 As the U-bit is transmitted in lockstep with the audio data, it is possible to maintain a defined and sample accurate reaction time between control data and audio data. One MIDI byte can be transmitted for every 10 sample periods. Through insertion of idle bits, it is theoretically possible to position MIDI messages in a sample accurate way.

5.3 Mode indication

The channel status bits shall indicate that the U-channel is carrying MIDI formatted data. The binary value 0110 in the channel status of the respective subchannel (byte 1, bits 4 to 7) is used to indicate this usage of the U-bit. This value is currently reserved.

NOTE The necessary amendments need to be added to IEC 60958-4. The amendment does not need to mention any particular application, such as speakers. The definition allows the transmission of MIDI data for any purpose. MIDI is a good match with IEC 60958 for several reasons: MIDI is an open-loop protocol that does not need a backwards channel, although it can take advantage of one, should it be available. The data rate of MIDI is within the same ballpark as the U-bit data rate in the IEC 60958 series. And MIDI is a general control protocol with a lot of flexibility for custom extensions, and a lot of support in the industry, for example in the form of hardware and software products. There are also various ways in which MIDI data can be transported in other interface standards, such as IEEE 1394, USB or other computer networks.

5.4 Subchannel usage

A receiver shall listen to the U-bit channel corresponding to the audio channel it is rendering. By default this would be the left subchannel. A loudspeaker rendering a mix of both subchannels shall listen to the U-bit data on the left channel. Transmitters would preferably send identical data on both U-bit channels, but this is not required.

If the IEC 60958 interface is in single channel double frequency mode, the U-bit channels of both subframes shall also be combined into one logical data channel, mirroring the situation for the audio data.

6 Loudspeaker command set

6.1 General

The command set is based on MIDI show control (MSC) commands as defined in the MIDI standard. Device operating parameters are set using the MSC SET command.

NOTE 1 Since there is no mandatory backwards data channel, the command set avoids backwards communication from speaker to controller as much as possible. The MIDI protocol shares the same open-loop philosophy, making it a good candidate for a base protocol.

NOTE 2 MIDI distinguishes between up to 16 devices. MIDI sysex messages, however, do not have this restriction and can address any number of devices. For example, MIDI Show Control (MSC) can address up to 112 distinct devices and 15 device groups.

NOTE 3 MIDI allows for vendor specific communication through sysex messages, which can be exploited by individual companies for their own purposes, such as custom features or firmware downloading.

NOTE 4 Attention is drawn to the various features already defined within the MIDI standard, such as MIDI file dump, which may be beneficial for speaker applications.

A loudspeaker shall support a way of receiving MIDI data. For example, this can be a standard MIDI port, or an IEC 60958-4 port with MIDI embedded in the U-bit, as described in Clause 5, or it can be MIDI embedded in a different transport, such as audio or data networks.

NOTE 5 It is strongly recommended to implement speakers in such a way that they are able to accept commands at any time. Introduction of a dead time after reception of a command greatly complicates the job of a controlling device. Also, it is practically impossible to define a dead time that suits every application.

NOTE 6 The command set described here is independent of the hardware interface used. Implementing the command set described here does not imply that the interface described in Clause 5 is used. A speaker is also free to implement several different interfaces through which it can be controlled concurrently.

NOTE 7 The provision of a backwards data channel is optional. If implemented, the method described in 7.2 can be used, but this does not preclude other alternatives.

6.2 Device identification and configuration

6.2.1 Device identification

By default, a loudspeaker only needs to respond to MSC commands with the broadcast device ID (7Fh). It is recommended that a manufacturer provides a means of associating the loudspeaker with a device id and/or group ID. It is left for the manufacturer to decide how this is done. Some possibilities are:

- the loudspeaker has its own user interface for configuring this. This can be as simple as a set of switches, or as sophisticated as a display and associated buttons/knobs;
- the loudspeaker can be configured through manufacturer-specific sysex messages;
- the loudspeaker supports a backwards channel and can identify itself to a controlling system, which may configure it automatically.

If so configured, a loudspeaker shall respond to messages addressed to its device or group id in addition to those with the broadcast ID.

A device by default only amplifies/renders a single audio channel. A stereo speaker/amplifier hence consists of two devices which can be given separate device IDs. The recommended way of controlling both channels together is through a common group ID. The same applies to multichannel formats, where a bundle of channels forming a multichannel speaker can be grouped together for common control. In this manner, any multichannel format can be supported using suitable grouping.

NOTE MSC reserves 112 IDs for devices and 15 IDs for groups. This limits the number of devices that can be controlled individually. It is legal, however, to have several devices with the same device ID. They will react to the same commands and hence cannot be controlled individually, except possibly using manufacturer-specific commands. If more devices need to be controlled individually, distinct interfaces will have to be used.

6.2.2 Auto configuration

Auto configuration requires a backchannel to be available. If so, the device shall recognize and respond to the MIDI identity request message.

The controller may use the response to identify all connected speakers, and make appropriate decisions as to how to configure them. It is beyond the scope of this standard to specify this, as the process is deemed highly application dependent.

Typically, after collecting the identity request responses, the controller assigns device and group IDs to all devices that allow this to be done via MIDI sysex messages. Then, each device will be configured with its initial settings. This can be done through a MIDI dump, or by recalling a stored configuration, or by sending the appropriate control commands.

The controller may need a description file for each device model in order to be able to configure it properly. The form and content of such a file is currently undefined and left for further study.

6.3 Parameters

6.3.1 Parameter identification

The loudspeaker is controlled through a number of parameters that can be set through MIDI messages. Each parameter has a control number associated with it that serves to identify a particular parameter. Each parameter also has a value range associated with it that defines the valid settings for the parameter. Controlling the speaker is done through MIDI messages that include control numbers and the new value for the identified parameter.

Control numbers for speaker parameters range from 0 to 8 191. The lower half of this range (0 to 4 095) is reserved for definition by the standard in the initial or future versions. The other half (4 096 to 8 191) is available for definition by manufacturers.

NOTE For manufacturer defined control numbers, the same number can identify entirely different parameters in different products. Correctly using those control numbers depends on knowing which product is being addressed.

6.3.2 Value range

There are two different types of parameters with their respective value ranges. One is a low resolution parameter, whose value range fits within 7 bits, the other is a high resolution parameter which needs 14 bits. Sometimes, a high resolution parameter can also be used with reduced resolution, by sending only the most significant 7 bits.

NOTE For binary parameters, the standard MIDI way is to treat them as a low resolution parameter with the binary value encoded in the most significant bit. That is, values from 0 to 63 represent off, and values from 64 to 127 represent on.

6.3.3 Setting a parameter

The standard method of changing a parameter's value is through the MSC SET command. Optionally, further methods can be provided, in order to increase flexibility and/or efficiency. It is the decision of the manufacturer whether those additional methods are implemented or not. The standard method shall always be kept available. Optional methods shall never make the standard method unavailable. See also 6.4.

6.3.4 Device addressing

A speaker shall react to MSC SET commands with the command format 16h (amplifier). It shall also react to the more general formats 10h (sound) and 7Fh (all-types). It may react to other command formats as appropriate. SET commands with unimplemented/unused control numbers are ignored.

NOTE 1 Control numbers used with the SET command are usually dependent on the device. The MSC standard only defines some control numbers for lighting devices, and leaves the control numbers for the other device classes entirely undefined. This standard proposal takes the liberty and standardises some of these control numbers for amplifiers (and implicitly for sound devices in general) in the interest of interoperability. Currently there is no provision made to prevent devices from using these control numbers in different ways, as the MIDI standard does not reserve any numbers for standardisation.

NOTE 2 A parameter with a given control number exists only once in a device (if it exists at all). Regardless which interface the commands are received through, regardless of the command format used, and regardless of the device ID used, it is always the same parameter which is addressed.

6.3.5 Timed parameter setting (optional)

The SET command can optionally carry a time, which specifies when the transition to the new value shall be complete. If the controlled device does not implement the time feature, it ignores the optional time specification within the SET command. If the time feature is implemented, it requires MIDI Time Code (MTC) to be sent to the device for time reference. Reception of MTC is a precondition for the time feature, if the device does not receive MTC it acts as if it did not implement the time feature.

NOTE With the optional time feature, it is possible to coordinate the execution of any number of commands on any number of devices, so that the effects appear simultaneous. Note particularly that the time specifies the end of a transition, not the start.

6.4 Optional alternative parameter setting through NRPN and/or MIDI controllers

6.4.1 General

This standard defines an optional method to change parameters through NRPNs or through standard MIDI continuous controllers. This includes a method on how individual parameters can be associated with a controller number or NRPN.

NOTE 1 Being able to control parameters using continuous controller messages can offer advantages when the speakers are to be controlled with standard MIDI software or hardware. A variety of tools are available which can emit such continuous controller messages as a result of user interaction, or in an automated way.

NOTE 2 Do not confuse control numbers and controller numbers. The former identify a speaker parameter, the latter identify a MIDI continuous controller. The association between the two must be explicitly made by the user. A fixed association between control number and MIDI continuous controller is not recommended.

The MSC SET command allows parameter numbers in the range 0..16 383. The first half of this range (0..8 191) is used for setting the new value of the parameter with the given control number. The second half (8 192..16 383) is used for associating the corresponding parameter with a MIDI continuous control or a MIDI continuous controller.

6.4.2 NRPN and MIDI continuous controller association

A parameter with control number N can be assigned to a MIDI controller or to an NRPN by sending a SET command with the control number N + 8 192, and sending the NRPN as the value. As a special case, NRPN numbers below 120 can not be assigned. They refer to

continuous controller numbers instead. As a special case within the special case, values from 32 to 63 refer to the LSB of double byte controllers, and assign the corresponding MSB, too (controllers 0 to 31). Values from 1 to 31 are reserved. A value of 0 deletes the assignment of this control number.

EXAMPLE: To assign control number 42 to continuous controllers 16&48 (MSB and LSB), send the following MSC SET command: $F0 $7F <device_id> $02 $16 $06 $2A $40 $30 $00 $F7.

EXAMPLE: To delete the previous assignment, send: $F0 $7F <device_id> $02 $16 $06 $2A $40 $00 $00 $F7.

NOTE 1 Assignments are only effective when a MIDI channel has been assigned to the device. Otherwise, the NRPN assignments are remembered but only become active after a MIDI channel is assigned.

NOTE 2 Controller numbers 6, 38, 96, 97, 98 and 99 (Data entry, data increment, data decrement, NRPN) should not be assigned if usage of NRPNs is desired. The effect of assigning NRPNs when one of these controllers is already assigned is undefined.

NOTE 3 Controllers 0 and 32 serve as bank select controllers by default. Assigning to them will make bank select inaccessible. Do this only if bank select is not required.

NOTE 4 Continuous controllers 120 to 127 are for channel mode control and cannot be assigned.

NOTE 5 Assigning a high resolution parameter to a continuous controller in the range 64 to 119 allows controlling the MSB of the parameter only. The LSB will be cleared to 0 whenever the continuous controller is set. If you want the entire parameter to be controllable through continuous controller messages, assign the parameter to a controller in the range 32 to 63.

NOTE 6 Unassigned continuous controllers or NRPNs have no effect.

NOTE 7 If several devices share a single MIDI channel, assigning different controllers still keeps them individually controllable.

6.5 Control numbers

6.5.1 General

This subclause specifies the meaning of the standard parameters and their control numbers to be used with the MSC SET command. The control number for standard parameters are in the range 0..4 095. The range 4 096..8 191 is reserved for manufacturer specific parameters.

6.5.2 MIDI channel assignment (control number 0, low resolution, optional)

This assigns a MIDI channel (1 to 16) to the device. By default, no MIDI channel is assigned and the device can only recognize sysex messages. A MIDI channel assignment allows the device to respond to MIDI commands that are channel-specific.

NOTE 1 The assignment of a MIDI channel is a precondition for NRPN assignment to be effective.

NOTE 2 Assigning the same MIDI channel to multiple devices is perfectly acceptable.

If MIDI channel assignment is implemented, implementation of channel mode messages should also be considered.

The value given in the SET command is defined like this:

- LSB is ignored and should be set to 0;
- MSB is 0 for deassignment and 16 to 31 for assigning MIDI channels 1 to 16, respectively.

Other values are reserved and should not be used.