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INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDELINES FOR THE USER INTERFACE IN MULTIMEDIA EQUIPMENT FOR GENERAL PURPOSE USE

FOREWORD

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IEC 61997, which is a technical report, has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
100/144/CDV	100/249/RVC

Full information on the voting for the approval of this technical report 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 3.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

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- withdrawn;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

This document which is purely informative is not to be regarded as an International Standard.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

There is growing use of multimedia equipment of every kind both in society and in the home; huge amounts of information are being exchanged both at the individual level and throughout society. However, as things stand it can easily be imagined that when this equipment is brought into the home, the complex and inconvenient operation seen as characteristic of multimedia equipment featuring electronic functions will make the equipment difficult, inconvenient and unprofitable to use; and incorrect operation may lead to confusion.

If the use of various multimedia appliances is to spread together with technological developments and the more advanced use of information, greater care than ever must be taken in the design of user interfaces that will make the equipment easy to use even by ordinary people who have received no special training in operating the equipment. The situation must not be allowed to arise where a multimedia appliance provokes a negative reaction because it is difficult to understand or difficult to use.

The designer is well acquainted with the appliance, the content of the system, and the peripherals; but a person operating the equipment for the first time starts with no knowledge at all.

The purpose of these guidelines is to take note of those inconveniences in the operation of multimedia equipment observed today, and to specify check-points that should be given primary consideration in the development of good multimedia products and systems that the general, non-professional user can use with confidence.

It is difficult to draw up detailed, concrete standards for products that have yet to be manufactured. In addition, the application to various appliances of standards drawn up over a period of time is impracticable in the field of multimedia, which is developing so rapidly. For this reason we believe it is essential for basic, minimum-level user interface guidelines to be drawn up at an early date, even if such guidelines are incomplete as standards.

The items taken up here are those concerned only with the problems of operation and use characteristic of multimedia equipment and systems, and assume the existence of detailed guidelines or standards for user interface recommended by various international bodies. Accordingly, other standards or guidelines as given in the annex should be consulted with regard to detailed ergonomic design standards and design standards shared with other, ordinary appliances.

Observation of these guidelines will lead to the kind of multimedia appliances that will satisfy user expectations, and at the same time will promote free competition in the development of multimedia equipment and systems.

GUIDELINES FOR THE USER INTERFACE IN MULTIMEDIA EQUIPMENT FOR GENERAL PURPOSE USE

1 Scope

This Technical Report applies to the designing of multimedia equipment such as information and communications equipment or audio-video equipment and systems.

In this report, multimedia equipment (systems) refers to equipment or systems mainly intended for use by the general public, either in the home or in public institutions. It is assumed that these products are meant to be used by anyone, including children, adults and senior citizens, using the equipment for the first time without any special previous training.

The scope of the user interface covered by these guidelines is limited to the problems peculiar to multimedia equipment.

Numerical details regarding user interface ergonomics, such as the size and spacing of switches, the expressive use of letters and pictograms, etc. are the province of the ergonomic standards and guidelines being considered by various organizations and are excluded from this report.

2 Reference documents

IEC 60447, *Man-machine-interface (MMI) – Actuating principles*

ISO 9241-10 to ISO 9241-17, *Ergonomic requirements for office work with visual display terminals (VDTs)*

ISO 13407:1999, *Human-centred design process for interactive systems*

ISO 14915-1 and -3:2000, *Software ergonomics for multimedia user interfaces*

ISO 1503: 1977, *Geometrical orientation and directions of movements*

TRON:1994, *Ken Sakamura eds., "TRON Human Interface Standard Handbook", Personal Media Co., 1994, in Japanese*

SIDE: *Structured User Interface Design and Evaluation Method (Research Institute of Human Engineering for Quality Life User Interface Committee*

3 Definitions

For the purpose of this technical report, the following definitions apply.

3.1
equipment
the term is used here, in general, for the home appliances, home automation systems, audio and video products, office machines, and automotive equipment

3.2
user
a person who operates the equipment

3.3
designer
a person who designs the equipment, and in particular the user interface part

3.4
interaction
bi-directional information exchange between users and equipment

3.5
user interface
software and/or hardware that manages interactions between users and equipment

3.6
invitation
initial feedback in proceeding to users' operations

3.7
operation
information sent by users to equipment or the action by users to send the information when the user extracts functions from the equipment

3.8
feedback
information sent by equipment to users or the action by equipment to send the information when the equipment shows the result of users' operation and/or internal states of the equipment to user

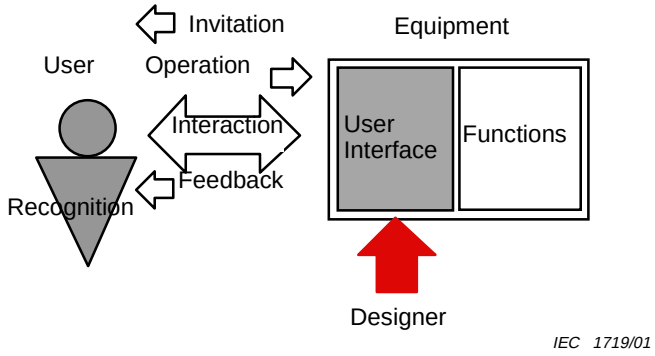


Figure 1 – The whole structure of human-machine interaction

4 Reference model of user interface in multimedia equipment

This clause gives a reference model, called "MAQ model", which illustrates the whole structure of user interfaces for multimedia equipment. This model is composed of three dimensions: 1) media, 2) abstraction, and 3) QOI (quality of interface).

The media dimension classifies user interfaces by the feedback media of equipment. It consists of visual, audio, mechanical, and others. The abstraction dimension classifies user interfaces by the abstraction of interactions. It consists of the lexical, syntax, and semantic layers. The QOI dimension classifies user interfaces by their quality in the equipment. It consists of the minimum, standard, and excellent levels. Figure 2 shows the MAQ model by a three dimensional figure.

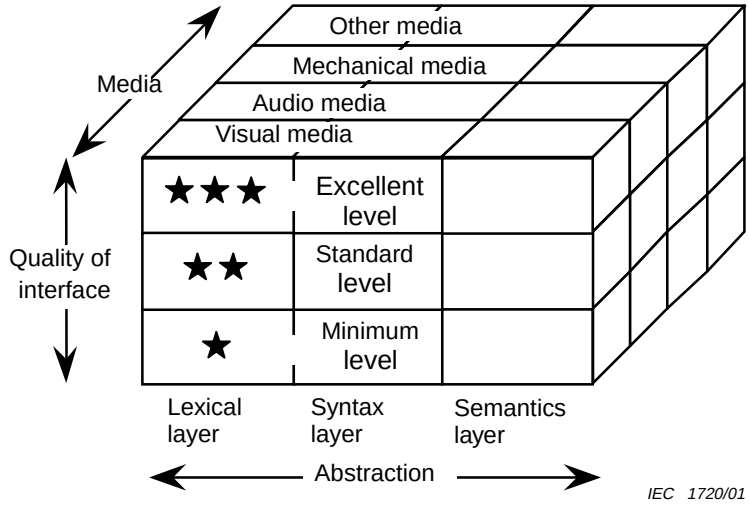


Figure 2 – "MAQ model" – Reference model of user interfaces for multimedia equipment

4.1 Dimension of abstraction

User interfaces can often be divided into three layers: 1) lexical layer, 2) syntax layer and 3) semantics layer. The lexical layer represents primitive operations and their feedback of basic input parts, and output methods of basic output parts. The syntax layer handles the way to compose the basic input/output parts. Concretely, it incorporates with the operation sequences and layouts of these parts. The semantics layer defines the relationship between user interfaces and functions of the equipment.

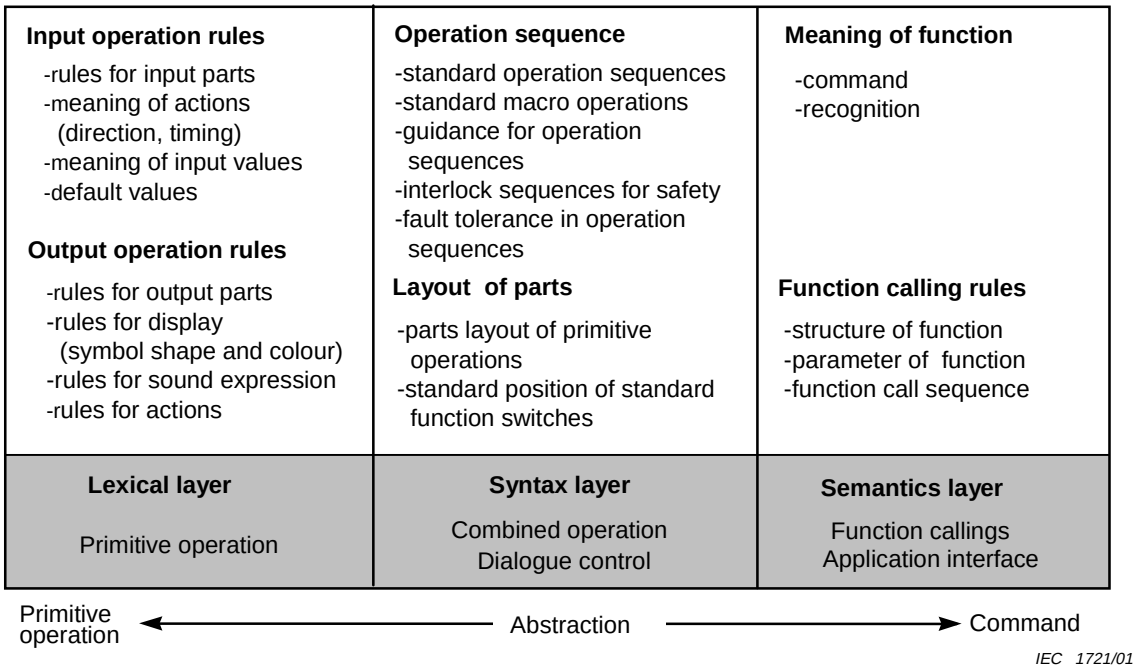


Figure 3 – Dimension of abstraction

4.2 Dimension of media type

Usually, multimedia equipment provides a function to exchange multimedia information with users. This capability is often used for user interfaces of the equipment, i.e. multimedia user interfaces. This means that user interface of multimedia equipment is often rich in its media. The MAQ model classifies user interfaces of multimedia equipment by its media types of feedback from the equipment.

NOTE Here, we do not refer to the types of media used for the operation, which is often called the “mode” of user interface. This guideline incorporates only mechanical types of operation.

This dimension classifies the media type into four:

a) visual media;

b) audio media;

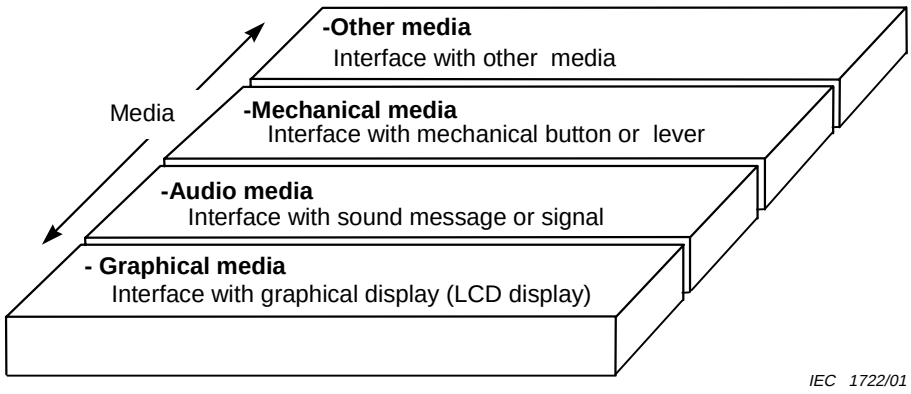
c) mechanical media, and

d) other media.

Visual user interfaces use special devices specialized for visual feedback. Examples are LCD displays, plasma displays, and so on. They show users visual information such as texts, graphics, animation, and video.

Audio user interfaces use sound for feedback. They include both speech sound and non-speech sound such as beep, buzzers, chimes, bells, and music.

Mechanical user interfaces use mechanical devices for feedback. Users can obtain information by viewing the mechanical devices and sometimes by touching them. Examples are physical buttons, slide bars, rotating volumes, and tilting levers.



There are other media for feedback such as smell and flavour. These media are classified into other media, but these guidelines do not handle this class of media.

Figure 4 – Dimension of media

4.3 Dimension of QOIs (Quality of interfaces)

The MAQ model classifies user interfaces by their quality. It consists of

a) minimum level,

b) standard level, and

c) excellent level.

Multimedia equipment of minimum quality level (represented as "★") allows users' operations with a minimum level of skills. This assures even first-time users of being able to control basic functions of the equipment.

Multimedia equipment of standard level (represented as "★★") considers capability of operations for the equipment. This assures even first-time users of being able to control every function of the equipment. Users can understand operation sequences to extract desired functions, and also the way to return from misoperation.

Multimedia equipment of excellent level (represented as "★★★") assures users of anxiety-free operations. This assures even first-time users of being able to control every function without anxiety and to feel comfortable.

Please refer to the next clause "Quality of interfaces (QOI) in multimedia equipment", for a more precise definition of each level.

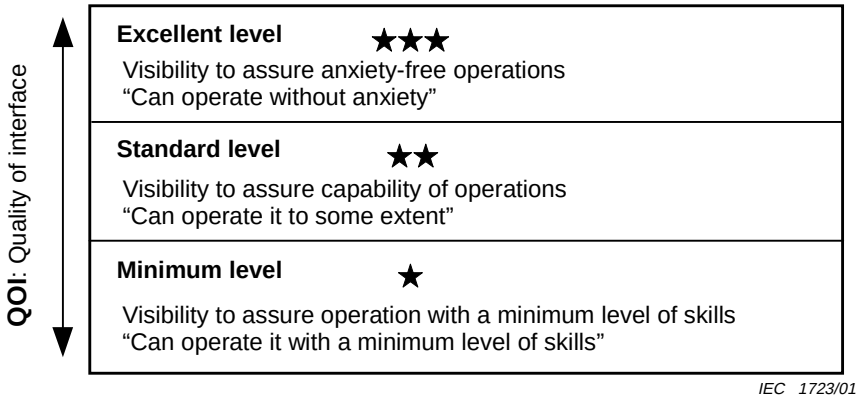


Figure 5 – Dimension of quality of interface

5 Quality of interfaces (QOI) in multimedia equipment

The main purpose of this guideline is to improve quality of interfaces (QOI) of multimedia equipment. Quality is a very difficult concept because it contains several criteria such as efficiency, easiness, and beauty. Which criteria are important depends on user classes, applications, environments for use, and so on.

5.1 Definition of QOI (Quality of interfaces)

The main difference between multimedia equipment and others is "invisibility" of its internal behaviour. The "invisibility" is the essential point that makes it difficult to use multimedia equipment. This invisibility has two causes. First, users cannot see the action of multimedia processing in the equipment. Second, users cannot see user interfaces and functions because of the complexity of multimedia equipment. Thus, user interface designer of multimedia equipment should pay attention to giving users simple and consistent "model" of systems or their behaviours. Of course, the model need not always be the same with its internal physical mechanisms. User interface should show some consistent models to users. From the above observation, these guidelines give a grade of user interfaces in terms of "how visible the multimedia equipment is".

Here, we recall the definition of three levels of QOI (quality of interfaces):

a) can operate with a minimum level of skills (minimum level);

b) can operate to some extent (standard level), and

c) anxiety-free operation for users (excellent level).

In the following clauses, we re-define these three levels of QOI in terms of “visibility” of system models.

NOTE Here, the term “visibility” means “*recognizability*” by any of the senses including seeing, hearing, touching, and so on. It does not necessarily mean recognizability by visual information.

5.2 Function level

To make precise definitions of QOI (quality of interfaces) below, here we define two levels of functions of equipment:

a) basic functions, and

b) optional functions.

Basic functions are functions which satisfy the primary requirements of the equipment. For example, basic functions of a CD player are to turn the power on/off, to play, stop, pause, skip forward/backward, and eject. For a telephone, they are only to make and to receive calls.

Optional functions are all functions other than the basic functions. For a television set, wake-up and sleep timer settings, brightness and/or contrast adjustment, and channel reservation are examples.

5.3 [★] Visibility to enable operation with a minimum level of skills

The first level requires visibility for the basic functions and visibility for lexical level of the basic and optional functions. This assures first-time users of being able to control basic functions of the equipment. The following statements are examples of this level of user interfaces.

5.3.1 “Easy to understand the purpose of the equipment”

- Any person seeing a piece of equipment for the first time should understand what it is for.
- Any person seeing a device should understand without difficulty that it is equipment for copying or printing, or that it is equipment that combines both functions. The purpose of the machine should be easily understood by any person who wishes to accomplish a task (send a facsimile or duplicate a document, for example). We have to anticipate such needs as the need to quickly identify the air-conditioner controller when it is hot or cold.

5.3.2 “Any person using equipment for the first time can easily start and stop it”

- A situation may occur when a person unfamiliar with equipment has to start or stop its operation. If a machine must be stopped because its continued operation may cause danger, or if a situation may be improved by the starting operation of a machine, any person should be able to quickly locate and use the start and stop buttons.
- The last person to leave the work place at the end of the work day, or someone at home, often has trouble with turning off the power to the equipment because they might spend much time in finding the on-off switch. So, any person seeing a piece of equipment for the first time should easily be able to switch the power on and off.

5.3.3 “A person unfamiliar with equipment can none the less operate it”

- Many devices whose emergence is envisioned will be designed to offer the convenience of multi-functionality. They will be difficult to use for people unfamiliar with their operation. This may result in an inability to operate them in a way that meets user requirements.
- Taking the facsimile as an example, the primary requirement is that anybody using it for the first time can perform the basic operation of transmitting a document without any need to refer to the manual. With a TV set, the primary requirement is that it can be used to watch programs of major TV channels.

5.4 [★★] Visibility to assure operations of capability

- The second level requires visibility of operation sequences for the optional functions. This assures first-time users of being able to control every function of the equipment. Users can understand operation sequences to extract a desired function and also the way to return from mis-operation. The following statements are examples of this level of user interfaces.

5.4.1 "Users can understand what to do next to achieve their requirement"

- Operating equipment for a given aim requires a predetermined sequence of operations. For users, this should be possible without memorizing the sequence.
- Automatic teller machines (ATMs) provide an example. They are designed in such a way that unfamiliar users can carry out transactions such as making deposits and withdrawals and checking the account balance by following step-by-step guidance.

5.4.2 "Users can understand to return from misoperation status (without resetting)"

- Some operations undertaken by multimedia equipment are invisible to the user, who cannot judge whether the operation is going well or stopped due to error.
- One problem is that equipment stops without explanation and the person operating it cannot find the means to restore normal operation. In some cases, this can result in such complications that the user has to repeat all the operation, from the very beginning.

5.5 [★★★] Visibility to assure anxiety-free operations

The third level requires visibility of current status of action for the optional functions. This assures first-time users of being able to control every function without anxiety and to feel comfortable. The following statements are examples of this level of user interfaces.

5.5.1 "Eliminate the anxiety of the invisible to confirm that tasks are completed"

- As stated above, one disadvantage of multimedia equipment is "invisible" operations. Users will become uneasy if they do not know whether a task has been complete, or if an operation is unsuccessful.
- Current equipment provides plenty of examples: Was a facsimile successfully delivered? Is the video timer set correctly? I pressed the function button, but did it work correctly?

5.5.2 "Operation should be done with confidence"

- Switches on electronic equipment that can be operated with a light touch without enough feedback often make users anxious.
- Since users cannot recognize their operation was accepted by the equipment or not, they tend to repeat operations again and again.
- While elaborating a response to switch depression in the switch itself is a significant task, using a light or sound to indicate when a switch is pressed may impart some confidence to users.

5.5.3 "Feedback of an operation should be felt realistically"

- With electronic equipment, a large volume of work can be manipulated in the same way as a small volume, or controlled by the same operation. This characteristic can lead to mis-operation or a misunderstanding that goes against the user's intentions.
- When an operator erases data or adjusts the temperature, there is no realistic sense of the action since the change is represented numerically. Providing a real sensation that large changes differ from small changes is an important means of preventing erroneous operation.

- The difference in response felt when turning a car steering wheel at different speeds is an excellent example of how the sensation of an operation differs with the volume of the change.

These definitions are summarized in table 1 below.

Table 1 – Definition of quality of interfaces

	Lexical layer	Syntax layer	Semantic layer
Optional functions	★	★★	★★★
Basic functions	★		
★: Visible in minimum level. ★★: Visible in standard level. ★★★: Visible in excellent level.			

6 Essential criteria for QOI (quality of interfaces)

From the view of designers, QOI (quality of interfaces) is attained by the combination of several factors given below. Each factor shows a concrete approach to the good quality of user interfaces.

6.1 Easiness

Easiness is the condition of the ease of operation that even novice users can operate the basic functions easily. This condition is closely related to perceiver, consistency, and certainty.

Example: Emphasized display of a basic operation set

Even in a high-grade audiovisual (AV) equipment with a wealth of functions, the operation panel should be designed so that users can first find its basic operation set such as play, stop, pause, forward and backward. Also, unnecessary steps are eliminated.

6.2 Efficiency

This is consideration of the efficiency of equipment operation. This is the condition that makes it possible to complete more processing in the same time by taking rational operation methods into account.

Example: Macro operation

A macro switch for repeating the same series of operations makes it possible to execute multiple operations by pressing just a single button.

6.3 Consistency

Even when we are surrounded by many different electronic products, we should not have to learn a large number of operations. Many of today's consumer products, for example, provide timer functions. The way these timers are set, however, whether to record a TV program or to turn audio equipment on and off at preset times, differs significantly from one product to the next. Users have to learn each method separately for each product.

To avoid this unnecessary confusion, it should be possible to apply a similar operation principle to all equipment that uses a timer function. Moreover, it should be possible to operate new equipment right from the start by inference from previously learned operation methods.

Example: Consistent relationship between direction of operation and setting value

For level meters and operation levers that move right and left, if the right direction is always for increase, then volume, brightness, speed, and other operations are easy to understand.

Example: Consistent operation grammar

A uniform operation order such as command-and-select, in which a user selects the target operation first and specifies the contents of processing next, makes operations easy to understand.

6.4 Perceiver

Perceiver is the condition of the intuitive quality of operation of the equipment so that necessary operations can be understood intuitively without needing to read the manual.

Example: Affordance

On a touch panel, a switch with a 3D view like a mechanical switch or button is better than a switch with characters of the switch name and its frame square.

6.5 Certainty

Certainty is the condition of the reliability of operations such that mistaken operations are excluded and the goal reliably attained.

Example: Guidance of operation

The certainty of operations can be raised by displaying appropriate guidance messages as the target operation is carried out by pressing symbols sequentially on the touch panel.

Example: Appropriate feedback

Changing the colour of a symbol on the touch panel when it is pressed notifies the operator that the operation has been accepted and shows the progress of the operation and thus increases the comfort and sense of reliability of the operation.

Example: One-to-one Response

Every input by users should provoke a perceivable response in the system, be it visual, audible, or both. This feedback not only gives users a feeling of control, it also confirms that the message was received. Avoid, for example, forcing users to press the “volume up” button three times before seeing the volume “bar” increment by one visual element.

Example: Match target and destination names exactly

When users select a target on a menu, and the system takes them to the indicated destination or new screen, the destination should be clearly labelled, and the label should match the exact wording of the original target button. For example, if a menu lists “Optional Features” the referenced screen should be entitled, not “Feature Options” or “Options” or “Select One” but “Optional Features” – the exact wording used in the target. If the best phrase does not fit one setting or the other, select the shorter one if it allows an exact match. This practice confirms correct communication (certainty) and helps users learn their way around the program.

6.6 Relief and comfort

This is the consideration of the sense of security and comfort in equipment operation. This is the condition for making it possible to operate with security and comfort.

Example: Small short-term memory

Command-based operations such as inputting function numbers depend on users' memory. On the contrary, menu-based operations do not need users' memory because users have to select only one item presented by the equipment. This small-memory principle greatly affects the user's ease and comfort.

6.7 Personal condition

Designers should consider personal condition of users. That is consideration for the operation location and user culture and customs. This covers the conditions given below.

6.7.1 Different life and culture depending on a country and a region

In designing user interfaces, designers should consider the culture and customs of the country and region where the users live. This is the condition that the operation method for the equipment be made suitable to these conditions.

Example: International coding

The telephone numbering system depends on the country and the interface can be designed so that specifying the country first makes the telephone number specification method conform to the numbering system of that country. Colour coding also depends on the culture.

6.7.2 Circumstance at using

In designing user interfaces, designers should consider the location where the equipment is used. This is the condition that operations be appropriate for the location where the equipment is used.

Example: Visible display even in the darkness

LCDs for equipment used outdoors can be transmissive types combined with back lighting rather than reflective types in order to improve visibility at night.

6.8 Social conditions

Designers should consider social conditions for equipment operation. This covers the conditions below.

6.8.1 Environment

In designing user interfaces, designers should consider environmental assessment for equipment operation. This is the condition that operation sections do not cause negative impacts on the environment during equipment operation and production or when the equipment is disposed of.

Example: Ecological design of I/O devices

The display section can be made a type that consumes less electricity, the operation display section can be made easy to disassemble in order to increase recyclability, and parts that do not negatively impact the environment can be selected in order to prevent the generation of pollution when the equipment is disposed of.

6.8.2 Child education

In designing user interfaces, designers should consider the raising and educating of children in equipment operation. This is the condition that operation sections do not generate negative impacts on children when the equipment is operated.

Example: Child lock

A mechanism is required that prevents children from accessing harmful web sites when they use the Internet.

6.9 Accessibility

This is consideration of accessibility in equipment operation and covers the conditions below.

6.9.1 Disabled persons

This is consideration of the disabled in equipment operation. This is the condition that the equipment be operated easily and with a sense of security even by those with disabilities.

Example: Option of speech recognition/voice guidance for the blind

In operation methods such as with touch panels, number keys can be combined with voice recognition and auditory guidance so that even the visually impaired can use the touch panel easily.

6.9.2 Senior citizens and children

This is consideration of the elderly and children in equipment operation. This is the condition that the elderly can also operate the equipment easily and that small children cannot cause any trouble by playing with the equipment.

Example: Large characters for the elderly

The letters on touch panels can be made large enough that even the elderly can read them easily.

6.10 Safety and health

This is consideration of safety and health in equipment operation and covers the conditions below.

6.10.1 Ergonomics

Ergonomics is the condition that operation sections are such that operating the equipment does not have negative impacts on health.

Example: Adequate size and shape

The size and shape of operation parts or their layout on an operation panel should be designed on the basis of adequate physical measurement of target users. Inadequate design of these conditions may cause fatigue or pain, and, in the worst case, the users will become ill.

6.10.2 Safety

Safety is the condition of user interfaces that operating the equipment does not cause danger or accidents.

Example: Confirmation of operation result before execution

For operations that include dangerous processing, accidental operation can be prevented by issuing confirmation messages before executing the operation.

Annex A

Guidelines for the user interface in multimedia equipment for general purpose use

This annex describes concrete guidelines for the user interface in multimedia equipment for general purpose use. Each guideline is accompanied by marks representing which quality level is accomplished by the guideline. Figure 5 above shows these marks.

[★★★] means **excellent level**, that enables visibility to ensure anxiety-free operations.

[★★] means **standard level**, that enables visibility to ensure capability of operations.

[★] means minimum level**, that enables visibility to ensure operation with a minimum level of skills.**

A.1 Media selection

User interfaces can be classified as graphical types, mechanical types, and auditory types depending on the type of equipment used. In designing user interfaces of multimedia equipment, designers can use all according to the characteristics of the equipment. This annex explains some features of each type, then suggests which should be used for each application.

A.1.1 Advantage and disadvantage of graphical user interface

A graphical user interface (GUI) is a user interface approach that combines a general-purpose display with input parts and optionally with voice controls, usually some kind of pointing device. The display allows text and graphics to be arranged freely, while the devices can indicate any portion on the display. The most important advantage of GUI is to allow text and graphics to be arranged freely, and that a GUI can contain parts which cannot be implemented as mechanical parts.

A.1.1.1 Advantages of GUI

A GUI operating method has the following advantages:

- the user selects or changes an item by indicating it directly;
- only the items to be set in a given instance need to be displayed at that time. This feature makes a GUI interface well-suited to situations where there are a large number of items that can be set;
- illustrations, lines and other graphical elements can be used to aid the user in understanding operations, making this approach suitable for complex interfaces.

A.1.1.2 Disadvantages of GUI

It has the following disadvantages:

- the display should be viewed in order to perform operations (making operation difficult for the visually impaired);
- it lacks the physical feedback of actual knobs and buttons, making operation difficult for those who should rely on their sense of touch;
- operation is not possible while the main power is switched off.

A.1.2 Advantages and disadvantages of mechanical user interface

Mechanical user interface (MUI) is the term we have given to mechanical parts such as knobs and levers, which are generally dedicated to a particular function. The advantages and disadvantages of MUI are the reverse of the ones for a GUI.

[★★★] Conditions for use of GUI and MUI

When a user interface is to be implemented for a given product, the choice between GUI and MUI is made by considering the features of both interfaces, as noted above. In the computer society of the future, as cost problems are gradually alleviated, the rate of GUI use can be expected to increase even further.

In any case, in order for users to be able to operate equipment in an environment that employs both GUI and MUI, it will be necessary to design interfaces so as to maintain a close affinity between GUIs and MUIs. The only real difference between the two types of interfaces involves the restrictions imposed by the kinds of input and display devices. The contents to be set are not really different.

When designing a user interface that employs GUI, we should always consider visually disabled users. MUI with mechanical parts can be operated depending on only the feeling of hands. However, replacing the MUI with GUI disables this operation. In may cases, this prevents visually disabled users from operating electronic equipment. Employing a GUI for a product, designers should consider support for visually disabled users.

[★★★] Conditions for use of audio output

Audio output is appropriate in some cases and not in others. Compared to visual display in GUI and MUI, audio output conveys information more slowly, and it is difficult to pinpoint the location from which the sound is emanating (see table A.1).

(see 6.1: easiness), (see 6.2: efficiency)

Table A.1 – Recommended conditions for audio output use

	Auditory display	Visual display
Complexity	Simple	Complex
Length	Short	Long
Later reference	Cannot be confirmed later	Can be confirmed later
Contents	Output items relating to time	Output items relating to space
Relation to action	Requires immediate action	Does not require immediate action
Relation to other display	When visual display is overloaded	When auditory display is overloaded
Operation environment	Too bright or too dark	Noisy environments (see below)
User's situation	Mobile	Stationary

[★★★] Multimedia user interface

Since multimedia equipment includes the ability to handle multimedia, it would often be the case that it provides a multimedia user interface. Some equipment provides feedback both graphically, mechanically, and auditory. To construct a multimedia user interface, it should be designed so that users can operate the equipment using any one media among them, not that they can operate it only by using all media.

For example, equipment with a graphical user interface with speech output should be able to be used by relying on only visual information OR only speech information.

A.2 Mechanical/graphical user interfaces

A.2.1 Lexical layer

A.2.1.1 Operation

[★] Relationship between operation directions and setting values

This indicates which direction a part should be operated for a specified value or action. They define positive notions/negative notions (see table A.2) and positive directions/ negative directions (see table A.3). If a given part is operated in a positive direction, the action thereby should be a positive notion. On the other hand, an operation in a negative direction will result in a negative notion.

(see 6.3: consistency)

Table A.2 – Positive notions and negative notions

	Positive notions	Negative notions
Position	Right, starboard, up, top, in front, tip	Left, port side, down, bottom, behind, tail
Direction of motion	To the right, upward, away from the user, clockwise rotation	To the left, downward, towards the user, counter-clockwise rotation
State	Light, warm, loud, fast, add, increase (+), accelerate, increase effects	Dark, cold, quiet, slow, subtract, decrease (-), decelerate, reduce effects
Action	To switch on, to close electrical circuit, to activate, to start, to tighten, fasten, to close valve, to ignite, to fill	To switch off, to open electrical circuit, to deactivate, to stop, to loosen, release, to open valve, to extinguish, to empty
NOTE The standards shown in this table are based on ISO 1503.		

Table A.3 – Positive directions and negative directions

	Positive direction	Negative direction
Push operation (push type)	Away from user	(In effect) towards user (*)
Pull operation (pull type)	Towards user	(In effect) away from user (*)
Slide operation (slide type)	Up, right, away from user	Down, left, towards user
Rotate operation (rotary type)	Down to up, left to right, clockwise	Up to down, right to left, counter-clockwise
Seesaw operation (seesaw type)	Up, right, away from user	Down, left, towards user
Tilt operation (tilt type)	Up, right, away from user	Down, left, towards user
* In the case of push-type parts, when the part is in the recessed, (On) position, a slight push releases the lock and returns the part naturally to its original, non-recessed position (Off). In this case, the operation itself is a push operation, but the effect is that the part moves towards the user. The converse is true of a pull-type part.		

In designing user interfaces, it is sometimes very difficult to determine which is left or right, and which is forwards or backwards. This is because the names of directions based only on the line of the operator's sight are often different from most user's feelings.

For example, because the direction of push operation of a push switch upon a panel facing up is "down (negative direction)", the push operation will set the switch to "off" (negative notion). This result does not match most users' feelings (see figure A.1).

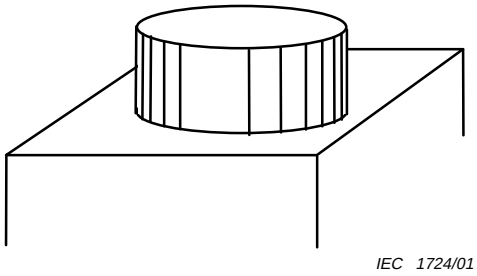


Figure A.1 – Push switch facing upward

[★] Coordinate models defining directions

This guideline defines coordinate systems to determine names of directions of movement within that system. The names of directions depend on the coordinate systems. They consist of the following three coordinate system models; for each type of equipment all user interfaces should follow one of the following:

- embedded equipment coordinate model (e.g. aircraft operation from the cockpit);
- stationary equipment coordinate model (e.g. personal computer operation);
- portable equipment coordinate model (e.g. headphone stereo operation).

(see 6.3: consistency)

a) Embedded equipment coordinate model

The embedded equipment coordinate model is a coordinate model that assumes operation panels embedded in walls and the like. The concept here is that the user is surrounded by a number of operation panels arranged on a rectangular parallelepiped. In this model, it is presumed that the user is always facing front, and the line of sight is perpendicular to the plane on which the panel is located. The direction perpendicular to the wall and away from the user is "forward (away)," and the opposite direction is defined as "back (towards)." "Up," "right," and "clockwise" for each surface are defined as shown in figure A.2.

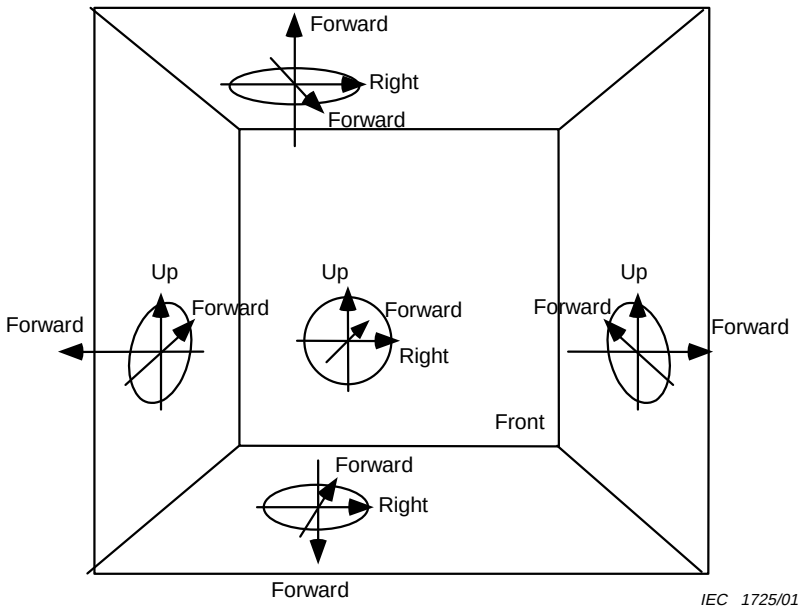


Figure A.2 – Embedded equipment coordinate model

b) Stationary equipment coordinate model

The stationary equipment coordinate model is a coordinate model for equipment that is normally used in a fixed position, such as most home appliances, a desktop computer, or telephone. This model assumes that the user faces the front of the stationary equipment. Accordingly, operations of parts attached to the side or back of the equipment are defined assuming they are operated from the front position, by extending the hands, rather than by the user moving to a new position. The stationary equipment coordinate model is illustrated in figure A.3.

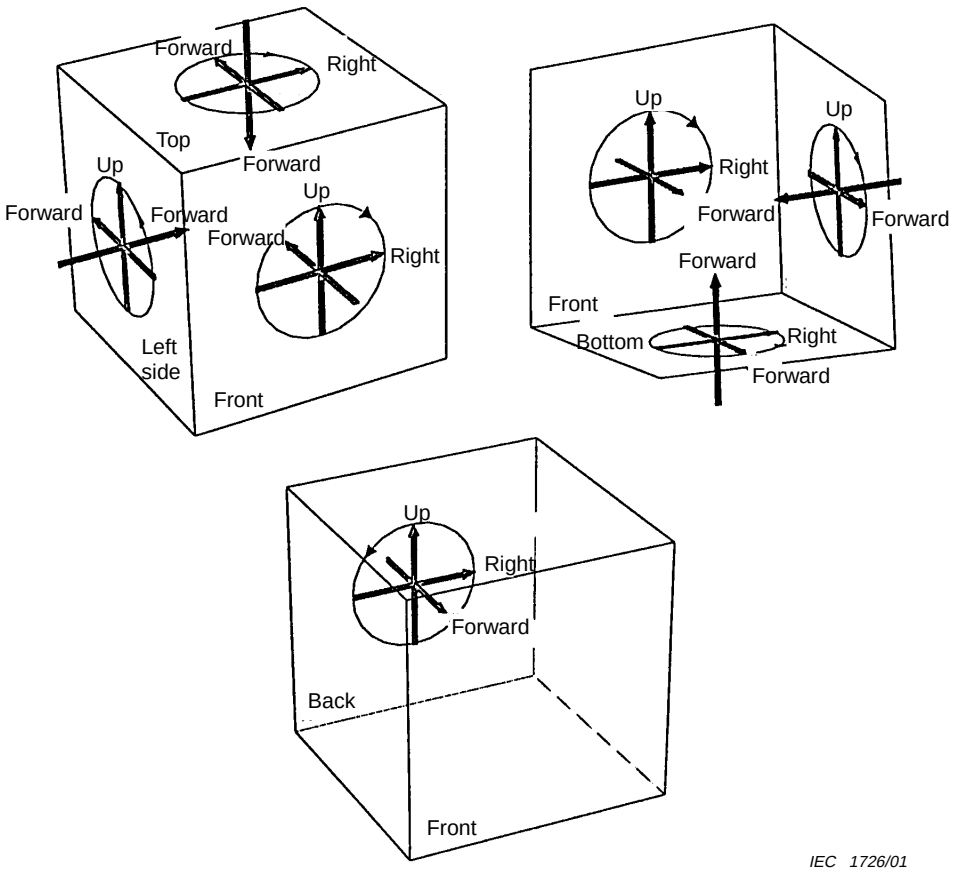


Figure A.3 – Stationary equipment coordinate model

c) Portable equipment coordinate model

In the portable equipment coordinate model, operation panels are arranged along the outer surfaces of the portable equipment, which is basically a rectangular parallelepiped. As with small camcorders and headphone stereos, it is assumed that operation parts can be located on any of the surfaces. A feature of portable equipment is that the positional relation between the equipment and the user is subject to change. That is, the user does not operate the equipment only from the front, as with stationary equipment, but operates it by orienting various surfaces toward the user. In this model, it is assumed that when operating the equipment, the surface with the operation panel is oriented towards the user. Directionality in relation to that panel is as shown in figure A.4.

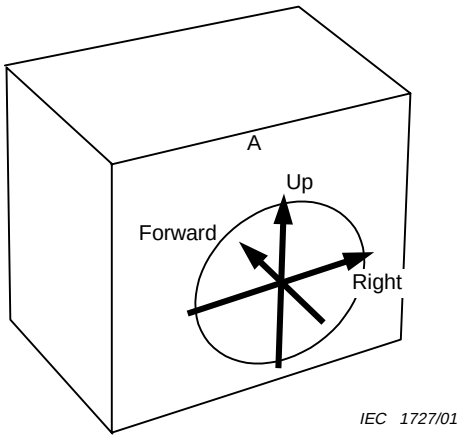


Figure A.4 – Portable equipment coordinate model

A.2.1.2 Visual feedback/invitation

<Colours>

[★★★] Design for clarity even when photographed in black and white

For clear visibility, displays should be designed with strong contrast between the background colour and display colour. For the sake of those with colour blindness, and for visibility in poor light, displays that rely only on colour for distinctions are to be avoided.

Use neutral colours of a middle or low value (brightness) as backgrounds for text, icons, buttons, or other graphics. Avoid strong, highly saturation colours, especially reds and oranges, which often strain the performance of television displays. Also avoid pure white (RGB 255, 255, 255), and be aware that the ability of a CRT to display black stops well short of a literal black (RGB 0,0,0).

(see 6.4: perceiver)

[★★★] Limit the number of colours

Except in special circumstances, design that uses more than five colours at once to convey meaning necessary for operation is to be avoided.

(see 6.4: perceiver)

[★] Colour coding principles

In the case of equipment that uses indicators to display status, use of colour is especially effective. Colour coding rules, for assigning meaning to colours, are discussed here (see table A.4).

(see 6.3: consistency), (see 6.7: personal condition), (see 6.8: social conditions)

Table A.4 – Colour coding

Colour	Meaning
White/black	Used for the background/display colours in text and graphic displays
Red	Danger, emergency, error
Green	Safe, normal, operating, on
Amber	Warning, caution

<Figures/icons>

[★★★] Ambiguity of figures

Skilfully used, figures can be an accurate and efficient means of expression; but it should be noted carefully that essentially figures are subject to ambiguity of interpretation. For this reason special care is needed in designing figures.

The following points should be aimed at for each of the attributes of figures and pictograms:

- consistency in overall use of figures and pictograms;
- ease of understanding;
- simplicity;
- ready familiarity.

(see 6.4: perceiver)

[★★★] Ease of recognition

Figures that are used in user interfaces should be readily recognizable from a normal distance in the lighting conditions assumed for the use environment.

(see 6.4: perceiver)

[★★★] Ease of discrimination

The meaning of figures should be clear even when used by themselves, and figures should be readily distinguished from other figures when they appear together.

(see 6.4: perceiver)

[★★★] Ease of learning

Figures used should be intuitive and easily remembered.

(see 6.4; perceiver)

[★★★] Simplicity

Figures should not use too many shapes, patterns or colours together.

(see 6.4: perceiver), (see 6.6: relievable and comfortable control)

[★★★] Aesthetic design

Figures should give a favorable impression. In some cases, however, clarity is more important, as in a "poison" mark.

(see 6.6: relief and comfort)

[★★★] Regard for other designs

Use of figures should take all due consideration for design trademarks and other such societal restrictions.

(see 6.7: personal condition)

[★★★] Consideration for inverse display

In the case of a GUI, the above guidelines should be satisfied even when the figure is inverse-displayed.

(see 6.4: perceiver)

<Feedback/Invitation>

[★] Indicating direction of operation

Where the direction in which a part is to be operated is not clear at a glance, it is recommended that arrows be used to indicate the direction (see figure A.5).

(see 6.4: perceiver), (see 6.5: certainty)

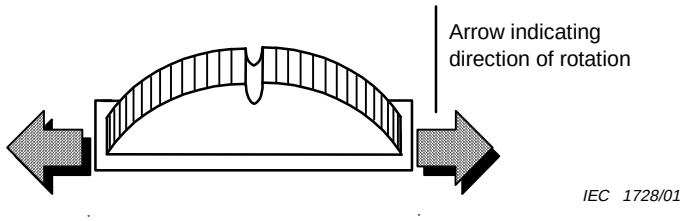


Figure A.5 – Visual indication of the direction of operation

A.2.1.3 Tactile feedback/invitation

Tactile attributes are parts attributes that depend on the human sense of touch for providing feedback on a) parts recognition, b) current status, and c) operations.

Considering that some users have visual disabilities, it is necessary to provide all parts with some form of tactile attributes. It is especially vital to provide tactile awareness of equipment status for the main power switch of heaters and the like, where a mistaken awareness of the current status might involve danger. The user interface design should also prevent mis-operation of switches in the process of probing for a tactile part.

[★] Standardizing direction of operations

The On/Off directions of switches should be designed in accord with the principles of direction of On/Off, positive/negative, increase/decrease.

(see 6.3: consistency)

[★★★] Indicating the direction of operations

In the case of parts for which the direction of operation is not clear at a glance, labels or other display parts are to be affixed indicating the direction. Also, for the sake of use by the visually disabled, it should be possible to determine the direction of operation tactually as well.

For the sake of visually impaired users, a method besides arrows allowing the direction to be discerned tactually should be used (see figure A.6).

(see 6.4: perceiver), (see 6.5: certainty)

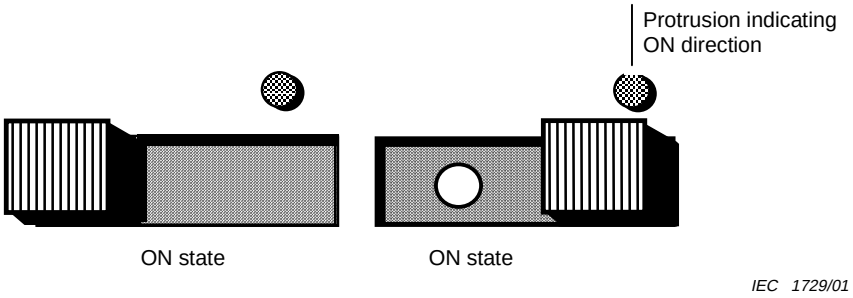


Figure A.6 – Tactile indication of the direction of operation

[★★] Graying inoperable parts

Inoperable parts for user interfaces should explicitly show their inoperability. For example, graying out of inoperable parts is the most popular method for the inoperability (see figure A.7).

(see 6.4: perceiver)

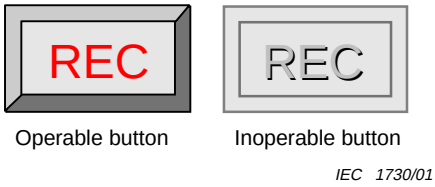


Figure A.7 – Grayed out button

[★] Affordance

Designers should design appearance of each operation part which indicates to most users how to operate it. For example, on a touch panel, a switch with a 3D view like a mechanical switch or button is better than a switch with characters of the switch name and its frame square.

(see 6.4: perceiver)

A.2.2 Syntax layer

A.2.2.1 Layout

[★★★] Cognitive distance

Group elements with a short cognitive distance, i.e. similar functions and subsystems, and use colour and shape to reinforce the arrangement in groups.

(see 6.4: perceiver)

[★★★] Simultaneous operation

Parts that are operated at the same time should be placed near each other.

(see 6.4: perceiver)

[★★★] Layout based on relative importance

In cultures where text flow is generally from left to right, highly important parts, and parts with a global significance affecting overall settings, starting from the upper left. Parts for auxiliary settings should be arranged at the lower right.

(see 6.4: perceiver)

[★★★] Display items

The most desirable user interface is one that displays all the items to be set, allowing them all to be viewed at once.

(see 6.5: certainty)

[★★★] Displaying a large number of elements

When there are many elements that must be looked at for one operation, they should preferably be arranged horizontally, not vertically.

(see 6.4: perceiver)

[★★★] Design operations to flow from upper left to lower right

In cultures where text flow is generally from left to right, arrange parts so that the operation flow is as follows:

a) the broad flow of operations should be vertical, from the top down;

b) within each horizontal array, operation should flow from left to right.

Overall, the flow of operations in a panel is like the flow of text in Latin-based languages (European languages), from left to right and top to bottom.

[6.3; consistency], [6.4; perceiver]

[★] Locate standard switches at the bottom of the panel or at the right

Standard switches such as the "Execute" switch or "Cancel" switch should be located at the bottom of the panel or on the right side.

[6.3; consistency], [6.4; perceiver]

[★] Locate switches for setting and executing the panel contents at the lower right

The "Execute" switch should be located farther to the right or lower than other standard switches.

The "Cancel" switch should be located farther to the left or higher than other standard switches.

[6.3; consistency], [6.4; perceiver]

As an example, figure A.8 shows the arrangement of switches at the lower part of a GUI panel on a microwave oven.

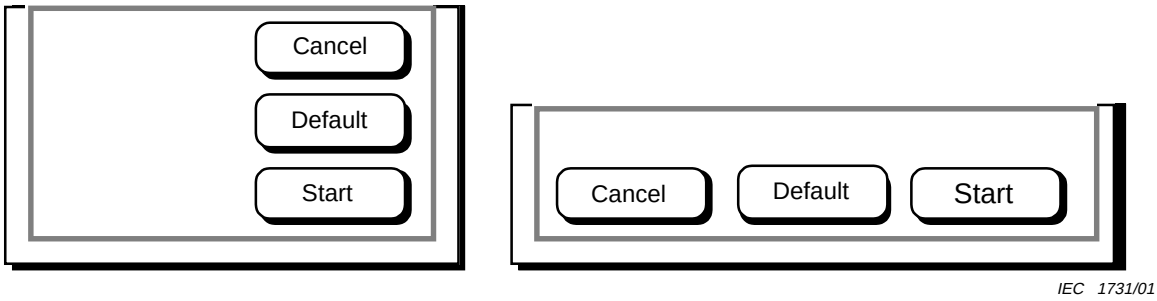


Figure A.8 – Switch layout on GUI panel

[★] Position input parts relative to the location of their objects of operation

Ideally, input parts should be located near to the object of operation.

If, however, they should be located at a distance from each other, the way they are mapped should be clarified by the way they are positioned relative to each other.

[6.3; consistency], [6.4; perceiver]

As an example, figure A.9 shows parts for setting the recording level on a tape deck, namely, input volume controls for the left channel and right channel and the corresponding displays.

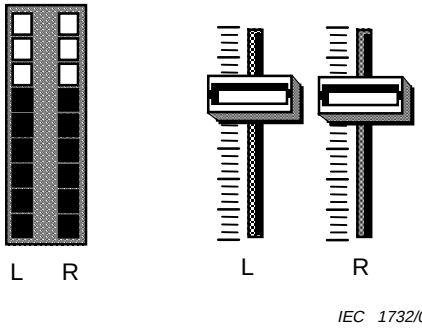


Figure A.9 – Mapping between display parts and input parts

Figure A.10 shows an easily grasped example for a gas range and its controls.

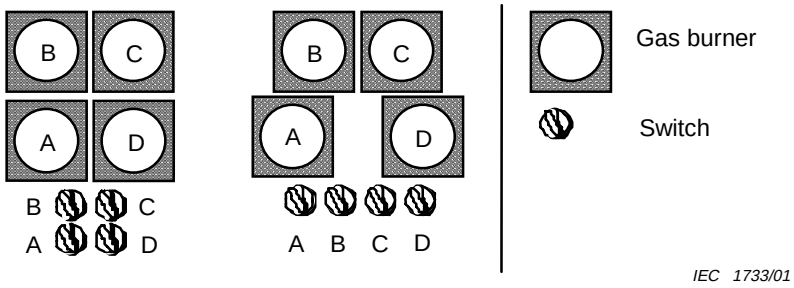


Figure A.10 – Mapping between gas range and control switches

[★] Mapping input parts to the direction of action of the object of an operation

Where the action of the object of an operation has directionality, the input parts layout should approximate that direction of action.

Figure A.11 shows an operation switch layout on a tape deck, for controlling the tape movement. In the good example, tape movement to the right is reflected in the switch layout. Moreover, the faster the tape movement is to the right, the farther to the right is the switch; and the faster the movement is to the left, the farther to the left is the switch.

In the two bad examples in figure A.11, the switch layout is unrelated to the direction of tape movement.

[6.3; consistency], [6.4; perceiver]

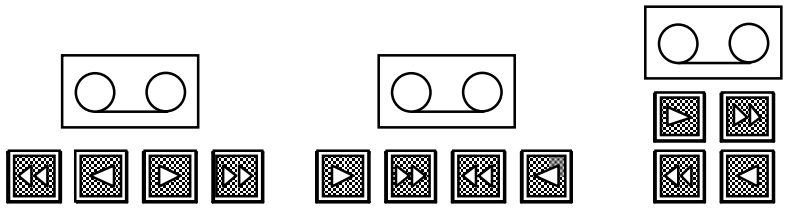


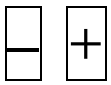
Figure A.11 – Correspondence between tape direction and switch position

[★] Mapping to positive/negative notions

Mapping directions to On/Off, Positive/Negative, Increase/Decrease, etc. are used to map the direction of parts operation to the notion of the equipment action activated by an operation. These tables are applicable not only to the direction of parts operation but also to parts layout.

[6.3; consistency], [6.4; perceiver]

For example, when two push switches [+] and [-] for increasing and decreasing numerical values are arranged left and right, the layout is as follows:



And when they are arranged vertically, the layout is as follows:

[★★★] Label position

As a rule, label position should be above the part if it moves left and right or to the left of the part if it moves up and down.

If at all possible avoid positioning a label such that it is hidden by the hand or finger operating it. The optimum design is one that allows the label to be seen whether the part is operated by the left hand or right hand. If this is not possible, the right hand is to be given precedence (see figure A.12).

(see 6.3: consistency), (see 6.4: perceiver)

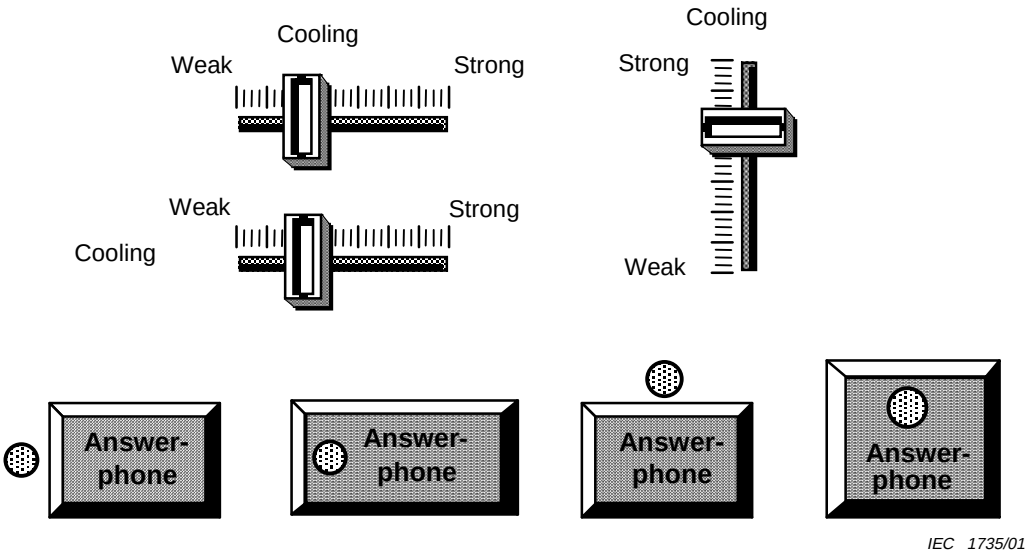


Figure A.12 – Label position

Since there is always the possibility that a label indicating the function of a part will be misread, the following additional guidelines are provided.

a) Standardize within one user interface panel. Avoid placing the label of one part above the part, and that of the next part below.

b) When the shape or parts layout makes it necessary to position a label in a less than clear relation to the part, make use of a frame or other mechanism to clarify the correspondence between label and part.

A.2.2.2 Operation sequence

[★★★] Correspondence of parts to parameters

Normally, when parameters are set by separate input parts and separate output (display) parts, for each parameter to be set there should be a corresponding separate input part and separate display part.

In the case of a mechanical operation panel, however, a large number of input parts may give the user an impression of complexity, requiring extra care in design.

(see 6.3: consistency), (see 6.5: certainty)

[★★] Revision of previous settings

It should be possible to go back and revise individual settings without having to cancel all the settings made so far.

(see 6.5: certainty)

[★★] Cancel operation

At any point in the setting process (at any item), it should be possible to cancel all settings made up to that point, and revert to the initial mode by pre-emptive transition.

(see 6.5: certainty)

NOTE For the visually handicapped who cannot get visual feedback and must rely on their sense of touch as well as their memory, it is often difficult to keep track of the current mode. A simple operation that reverts to the initial (reset) mode is of benefit in such situations.

[★★★] Provide macros with a high likelihood of being used

Macros that are most likely to be used should be provided by the designer.

(see 6.2: efficiency)

[★★★] Default setting

User interfaces to set certain values should first hold default values that would be set most likely in the situation.

(see 6.2: efficiency)

[★★] Step-by-step guidance

For first-time users and/or for multi-stage operations of optional functions of equipment, a user interface should provide users step-by-step guidance for operations.

(see 6.4: perceiver)

[★★] Visibility of current status of an operation sequence

To increase certainty of user's operations, a user interface should show the current status of the operation sequence. This function avoids users losing track of the operation phases and helps users to confirm acceptance of their operations. Also, this function helps users to recover from misoperation.

(see 6.4: perceiver)

A.2.3 Semantics layer

A.2.3.1 Visibility of actions of equipment

The most significant problem of user interfaces of multimedia equipment is the "invisibility" of its internal actions. "Media" by itself is information, which humans cannot see directly.

[★★★] Showing its internal states

Without explicit presentation of internal actions, i.e. multimedia handling, users cannot obtain information on how the equipment is working. Designers should be sure to show a wealth of information on the internal status of equipment.

For example, every kind of media player such as video players, DVD players, and MD players should display its current action such as recording, playing, pausing, and reviewing/cueing.

(see 6.4: perceiver)

A.2.3.2 Security

Security attributes are operation parts attributes relating to the following safety aspects:

- preventing misoperation;
- permitting operation only by authorized users.

Covers

Covers are placed on input parts, display parts or panels for the following two purposes.

a) To prevent misoperation

On portable equipment such as a headphone stereo, a cover might be placed on operation parts to prevent them from operating by mistake due to vibration.

In a GUI, to prevent misoperation, for important operations that cannot be reversed (e.g. deleting a file), it is necessary to display a confirmation panel to make sure of the user's intention before executing the operation.

b) To conceal parts with low use frequency

Including parts with low use frequency in a panel with parts in ordinary use would make the panel too complex and confuse users. To avoid this, a cover can be used to conceal the infrequently used parts.

When making use of a cover in the above ways, the following conditions should be met.

[★] Safety

If parts that must be operated in an emergency are located under a cover, safety will be compromised.

(see 6.10: safety and health)

[★] Individual differences

It should be kept in mind that some users are unable to open a cover or can open a cover only with difficulty.

(see 6.7: personal condition], (see 6.10: safety and health)

Key attributes

A key attribute, in the case of a mechanical user interface, is the quality of a part so that it cannot be operated without first inserting a physically correct key. A typical example is a car ignition switch.

In a GUI, a key attribute is the quality of a part such that a proper password or other such means is required before that part can be operated.

[★★★] Application scope of key attributes

Key attributes are to be used for the main power and other such places where high security is required. The key attribute of a car ignition switch, for example, is a way of preventing theft.

Also, by requiring a key to operate the main power switch, unauthorized use of equipment can be prevented physically. Another case where a key attribute can be used is for preventing children from operating equipment that might be dangerous. This use of a key attribute is commonly known as a child lock function.

(6.10: safety and health)

A.3 Auditory user interfaces

A.3.1 Lexical layer

[★★★] Volume (sound level)

The sound level of audio output must be high enough to be understood readily. The actual sound level should be chosen in consideration of the probable use environment, including noise levels.

(see 6.4: perceiver), (see 6.6: relief and comfort)

Excessively high and low frequencies should be avoided. The elderly, in particular, may have difficulty hearing sounds above approximately 3 kHz.

(see 6.4: perceiver), (see 6.6: relievable and comfortable control)

[★★★] Length of audio output

Excessively short/long audio output is to be avoided, since the user might not notice it. When an audio segment is longer that 3 s to 4 s, users should be able to skip through it.

(see 6.4: perceiver), (see 6.6: relief and comfort)

[★★★] Audio output rise time

Sudden bursts of sound may startle the user and cause a reflex action. Design the audio output to avoid this.

(see 6.4: perceiver), (see 6.6: relief and comfort)

[★★★] Audio output rhythm

Human beings recognize audible signals more by rhythm (succession of different sounds) than by pitch (frequency). For this reason, audio output should consist of a discontinuous pattern of different sounds.

(see 6.4: perceiver), (see 6.6: relief and comfort)

[★★★] Audio output complexity

Many user interfaces in use today output a wide variety of sounds, but in reality the number of different types of sounds that can be distinguished by human beings is relatively small.

(see 6.4: perceiver), (see 6.6: relief and comfort)

[★★★] Converting text to voice output

When characters or text are read by means of (synthetic) voice output, it must be remembered that there are some contents that can be distinguished visually but not when subjected to voice processing. Examples are upper case letters versus lower case, or italics versus normal type. One way to enhance such distinctions is to use both male and female voices, especially in the case of user interfaces for the visually impaired.

(see 6.4: perceiver), (see 6.6: relief and comfort), (see 6.7 personal condition)

[★] Considerations for hearing impairments

Considering that some users have hearing impairments, output and feedback should not rely solely on audio.

(see 6.4: perceiver), (see 6.7: personal condition)

A.3.2 Syntax layer

A major characteristic of an auditory user interface is that it takes a long time to output information because it is a serial media.

For example, consider an auditory user interface to let users select an item from N choices. On a GUI, these choices are visually displayed on a screen, and users select an item by using pointing devices or buttons. As users become familiar with the interface, the time to find a required item becomes shorter.

On the other hand, a naive auditory user interface will present the N choices by reading all. This takes a long time, and users cannot shorten the time by training.

Thus, it is sometimes pointed out that auditory user interfaces generally take a longer time than visual user interfaces. Especially, familiar users tend to be annoyed by this period. To solve this problem, the following guidelines are important.

[★★★] Simplicity

To shorten interaction time, unnecessary verbose output should be avoided as possible.

(see 6.2: efficiency of control), (see 6.6: relievable and comfortable control)

[★★] Skipping

Users should be able to interrupt auditory output and skip to the next step of the interaction.

(see 6.2: efficiency of control), (see 6.6: relief and comfort)

[★★] Replay

Users should be able to replay missed auditory output repeatedly.

(see 6.4: perceiver), (see 6.6: relief and comfort)

[★★] Operation during reading

Equipment should be able to accept users' operations even while it is outputting explanation or choices.

(see 6.2: efficiency), (see 6.6: relief and comfort)

[★★] Timeout

If a user is silent for some period after indicating choices have been presented and prompting the user for an operation, the equipment should display and ask again. If the user is still silent after repeating this process a few times, the interaction should be cancelled.

(see 6.2: efficiency), (see 6.5: certainty)

[★★★] Privacy

Auditory output passes further than visual output. Equipment should avoid outputting user's private information by using sound so as not to be heard by third persons.

(see 6.7: personal condition)

[★★★] "Operation-action" or "action-operation"

There are two ways to present choices: the "operations and actions" order and the "actions and operations" order. An example of the former is a message as "Press A, then B starts". On the other hand, an example of the latter is a message as "If B starts, press A". This guideline recommends the latter order.

(see 6.2: efficiency), (6.5: certainty)

Normally, users turn their attention to actions or functions of equipment. In the "operations and actions" method, users must hear each operation carefully and remember it until the corresponding action is displayed. On the contrary, in the "actions and operations" method, the users have to hear and remember only one operation after hearing the action name they wish.

[★★] Turn taking

In the speech interface, users may sometimes get confused whether they should start their operation soon or wait for the next guidance from the equipment. Thus, equipment should clearly prompt users operation, for example, by using an explicit turn taking sound.

(See 6.4: perceiver) (See 6.5: certainty)

[★★★] Representation of attributes of characters

In a naive auditory interface, users cannot distinguish character attributes of indicated information. Examples of such attributes are caps information of alphabets and the class of Hiragana/Katakana in Japanese. Equipment requiring the distinction should change tone colours to represent each attribute, for example a male voice for large caps and a female voice for small caps.

(see 6.4: perceiver) (see 6.5 certainty)

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