Appendix I — Rationales for the Standard[1]

1.0 Introduction

This appendix presents facts and considerations behind the specifications in the Power Control User Interface Standard. Other appendices address specific issues in detail, but this one covers the broad scope of the issue and standard.

The standard emerged from a combination of a review of user interface literature, examination of the operation and design of current products, and consideration of how principles could be applied across a wide range of products and contexts to have both simplicity and flexibility.

It is good interface design practice to not change designs unless there is a compelling reason to do so. Current product design has been informed by some design insights and market-driven evolution, so that some deference must be paid to the status quo. Thus, when there is not a problem with it, standardizing that practice which is most common is the default choice. Other key priorities are simplicity and internal consistency.

It is helpful to divide the standard into two parts. The first can be called the *hard* or *static* interface[2] — switches, indicators, and the terms and symbols around them. The second is *dynamic*, covering the *behavior* of devices over time.

There are several reasons for this organization: The hard parts of the interface are what we first encounter with a product (and are sometimes all of the interface); they have more limitations than other parts of the interface; they are more universal (they apply to nearly all products whereas other aspects apply only to subsets); and it is easier to adapt the other parts of the controls to the hard portions than vice-versa.

It is helpful to keep in mind that the standard was developed with electronic devices (office equipment and consumer electronics) as the primary focus, as these have the most complex power control user interfaces. However, the standard is intended to be applied to any device[3] that has some electronic character, which is an increasingly larger number including many appliances and even automobiles.

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[1] [1] This appendix provides detailed background information about the development of the Power Control User Interface Standard. For the full report and more about the Standard, see http://eetd.LBL.gov/Controls

[2] Per Appendix II, the "hard control panel" is "control panels with conventional controls and displays", in contrast to display-based controls that may mimic hard controls or software interfaces.

[3] Several text conventions are used throughout this report. The terms "amber", "yellow" and "orange" are taken as synonymous (amber is used here). Basic power states are italicized, such as *on*, *sleep*, and *off*. "Device" means a distinct electronic product that can operate on its own (some electronic discussions reserve device to mean an entity within a computer such as memory, an add-in card, and such). There is no distinction made between the idea of a "power state" or "power mode".

1.1 Structure

Table 1 presents key concepts related to the User Interface Standard. The Standard is built around these, derived from current implementations of them, and to be implemented in future ones.

Table 1. Key Concepts in Power Control User Interfaces

States	Devices have basic power **states** that are shown by *indicators* and changed by controls. They have names (terms) and graphic representations (symbols), and standard indicator colors or behavior. There are basic states, substates (e.g. levels of sleep), and times of transition between states.
Controls	Controls can be manual controls (e.g. switches) or automatic controls (e.g. timers). The behavior of controls may be fixed, or adjustable by software control panels.
Manual Controls	Manual controls include switches, buttons, lid switches, and signals from objects that function as part of a device (e.g. a keyboard or mouse). The controls can be labeled with terms and symbols and may have integral indicators.
Automatic Controls	Automatic controls can be based on time (e.g. time of no activity or real-time-clock alarms) or external input (e.g. network activity or another connected device as a PC controls a monitor).
Indicators	Most commonly colored LED lights, but also (portions of) displays generally, and audio and tactile indications. Light indicators can be labeled with a term, symbol, or be associated with a manual control.
Software Control Panels	These can change the behavior of manual or automatic controls. There is a name (and possibly a symbol) for the panel as a whole, and it may use terms, indicators, and symbols within it.
Terms	There are names of states, user interface elements (e.g. “power button”), manual controls, automatic control options, and indicators. Terms need to be translated into each language.
Symbols	Symbols represent power states and / or controls to change state. There is usually a term associated with each symbol. Some symbols are nation-specific, but most are intended to be global. They can appear on the outside of devices and on displays.
Documentation	Instructions for how a product works and is to be used can appear on the product, on printed manuals, on-line, or on the product’s display. All user interface elements may be described in the documentation.

The combination of controls, indicators, and states that a particular device has can vary tremendously. In addition, the physical arrangement and location of interface elements also varies widely. This is a combination of the diverse needs of the devices, reasonable aesthetic and design choices, and variation without any apparent purpose or value. Even within the category of office equipment, there are devices without switches, without indicators, without labels, and one without any of these[4].

2.0 Overview

It would be easiest to explain and organize this presentation by treating each part separately; however, this cannot be done. There are close linkages among them and there is not a simple ordering in their derivation. Thus, there is first a review of what the standard specifies, and then a discussion of each portion of it. The discussion of each part presumes as given the other parts of the standard. A few parts of the rationale are discussed elsewhere, such as the crescent **moon** symbol for sleep (Appendix VI) and how to treat the **hibernate** mode (Appendix VIII), but these also follow the pattern of taking as given the other parts.

The Hard Interface:

- Use only three basic power states: *On*, *Off*, and *Sleep*.
- Use the word "Power" for terminology about power.
- Use the ⏼ and ⏻ symbols to mean "power". ⏼ guarantees that *off* always means zero power but should only be used when that is important. (This requires changing the ISO / IEC standard).
- Adopt the "green / amber / off" color indications for power indicators. Red should be reserved for warnings, alarms, or errors.
- Use the "*sleep*" metaphor for entering, being in, and coming out of low-power states; use the moon symbol for *sleep* — ⏾.
- Present "hibernate" modes to the user as forms of Off.

Dynamic Behavior[5]:

- Use "power up" to mean turn on or wake up, and "power down" for turn off or go to sleep.
- Use flashing green on the power indicator for powering up and flashing amber for powering down.
- Provide optional audio indications for power state transitions.
- Alternating green / amber can be used to mean error if red is not available.
- The power button toggles between the two most common power states.
- When a device is *asleep*, pressing the power button will (usually) wake it up.
- Holding down a power button for an extended time will trigger an emergency action.
- Usually, when a device is *asleep,* the input causing a wake event should be discarded.

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[4] In 2000, we found a low-cost inkjet printer with no labels, indicators, or switches. It was always on when plugged in, and all indications were accomplished on a software control panel on the PC it is connected to. With no indicators or switches, there is no need for any power-related labeling.

[5] An additional recommendation to "Provide icons to show what types of input may be active" was dropped as not being sufficiently developed for inclusion in the standard.

Again, each principle presumes the others.

2.1 States

The User Interface Standard is concerned with **power states**. Devices also have other states, often "functional states" such as being connected to a network (or not), imaging (or not), and displaying media content (or not). While functional states are often correlated to power states (e.g. a device can perform some functions only while *on*), only changes in power states should determine the power user interface. Device power states are a combination of their electrical and functional characteristics. All devices have an "unplugged" state (or battery removed if they can be run from a battery) which is one type of *off* state, and all have at least one *on* state.

Most devices currently have either two *basic* power states (**on** and **off**) or three (on, off, and a **low-power** mode). The standard specifies that devices be limited to these three basic states. Indicator colors, capability, switch operation, and overall behavior should be consistent within each basic state. Any additional states should be variants of one of the basic states rather than a fourth basic state. For example, rather than be a separate mode, "hibernate" should be a form of *off* (see Appendix VIII for an explanation of why this is best). Also, multiple low-power modes can be all be types of a basic *sleep* mode.

The possible alternatives to there being three basic states is to have two or four. Two basic states is not enough; we currently have a user interface vocabulary built on two states and it has caused a great deal of confusion around power control. Low-power states are sufficiently different from *on* or *off* states that they cannot be successfully mapped into them on most devices. Four states adds significant complexity over three, and there is not evidence that suggests that this burden on users is needed. Devices need not have all three states; many lack a *sleep* state, and some have unplugged as their only *off* state. So, the *possibility* of three states does not burden devices with states that they don't need.

The idea of mapping internal states to fewer external ones is not new. For example, the ACPI specification defines a few "Global System States" that are apparent to the user and many more System States. ACPI provides for multiple sleep states (that may be identical in outside appearance), and device and processor states (which are not made apparent to the user).

The "hibernate problem" is addressed in Appendix VIII. That discussion identifies criteria by which to categorize power states, six possible solutions to the "hibernate problem", and issues and problems with each solution. The conclusion based on all of this is that the solution of mapping hibernate to be a form of the *off* state has the least problems.

2.2 The Term "Power"

It is helpful to have one idea and term to organize power controls around. For terminology about power controls, the standard specifies that the term "power" should be used, such as "power button" (or power switch), "power indicator", "power control panel", etc.

Power is the most common generic term in this area. Next (but far less common) is "energy" as in "energy saver" and "ENERGY STAR". However, the terms "Energy button", "energy indicator", "energy management", and "energy control panel" sound odd to the ear or suggest concepts different from those intended. From usage on current devices there are no other candidate terms, there is no reason to consider a new term, and no need to question the existing dominant usage of “power”.

The word need not be used on the hard interface itself. A standard translation needs to be identified for each language[6].

In addition to the term, standard affordances of power should be utilized such that *on* is up, to the right, clockwise, etc. (see Appendix V).

2.3 Power Symbols

With a common organizing principle for power controls — “power” — it makes sense to have a graphic symbol that is a synonym for this basic term for simplicity and for language independence. The symbol can then be used for different purposes, such as a power button, power indicator, or power control panel. The standard provides that the ⏻ symbol should be used to mean “power”. This is consistent with common design practice on electronic products, but not directly with existing international standards for graphical symbols (shown in Table 2)[7].

The current symbols and definitions cannot be applied to modern devices in a way that is consistent and readily coherent to ordinary people. Modifying and supplementing them is essential. For those who find a problem with the content of the User Interface Standard, the only useful response is to propose an alternative system which is better and has fewer or less severe problems.

The most common and prominent power control is an on / off switch with a power indicator nearby. The most common labeling of this on current products is the ⏻ symbol. It seems (though we did not quantify the effect) that there is a shift away from the ⏼ symbol. We speculate that designers find ⏻ more visually appealing. Also, more devices consume power while off and so cannot use the ⏼ symbol.

⏻*: A Summary*

For graphic symbols, there is a the original need which propels their creation, the context in which they are used, their incarnation in standards, popular understanding of them, and the best ways to apply them to future products. It is instructive to review these for the ⏻ symbol.

- Need: The ○ and ⏼ symbols quite specifically require that the “off” position be a mains disconnect and indicate guaranteed zero power consumption and consequently no possibility of electrical hazard in that *off* mode. Controls that didn’t meet this strict criterion required a different symbol — hence the introduction of ⏻.

[6] It is possible that “power” will become an international standard word in the way that “STOP” has become, transcending English. This should not be forced nor relied on, but accepted if it occurs.

[7] The international standards also have an on-off symbol for “momentary on” buttons (a circle with a T in it). We have not observed this in use on office equipment or consumer electronics and recommend against its use on them. However, it may have good uses in other areas (e.g. heavy machinery) and so an appropriate part of the international standards. There are also variants of the key symbols for “remote station” or “part of equipment” which also are used infrequently, and with dubious comprehension by users.

Table 2. IEC/ISO Graphical Symbols related to power status

Symbol	Name/Number	Definition
⏽	"ON" (power) IEC 5007, JTC1 001	To indicate connection to the mains, at least for mains switches or their positions, and all those cases where safety is involved.
⭘	"OFF" (power) IEC 5008, JTC1 002	To indicate disconnection from the mains, at least for mains switches or their positions, and all those cases where safety is involved.
⏻	Stand-by IEC 5009, JTC1 010	To identify the switch or switch position by means of which part the equipment is switched on in order to bring it into the standby condition.
⏼	"ON" / "OFF" (push-push) IEC 5010, JTC1 003	To indicate connection to or disconnection from the mains, at least for main switches or their positions, and all those cases where safety is involved. "OFF" is a stable position, whilst the "ON" position only remains during the time the button is depressed.
	Electric energy ISO 0232, JTC1 008	To signify any source of electric energy, for example on devices starting or stopping the production or use of electric energy.
	Pause; interruption IEC 5111, JTC1 011	To identify the control device by means of which the run (e.g. of a tape) is interrupted by means of a break mechanism and mechanical disconnection from the driving mechanism which continues to run.
◡	Ready ISO 1140, JTC1 009	To indicate the machine is ready for operation.

Notes: In IEC 13251, the definition of 5010 ON / OFF ends with "Each position, "ON" or "OFF" is a stable position.
IEC numbers are from IEC 60417. ISO numbers are from ISO 7000. JTC1 numbers are from ISO / IEC 13251.

- Context: The power symbols were originally used in hard interfaces only, but now also arise on displays. Similarly, they were introduced before electronics became so widespread and before the rise of automatic controls. A problem with ⏻ is that it was not clarified in the beginning how it was intended to be used, to be simple, clear, and consistent.
- Standards: The definition of ⏻ (as cryptic as it is), indicates that it is to be used to identify a *state* (like *on* or *off*) as well as a *control* (like a power button); this is in contrast to the other symbols which specify only a state (⏽ and ⭘) or a control (⏼).
- Popular understanding: The popular understanding of ⏻ has come to mean "power" or "power on" (see below). The distinction from ⏼ is technical (safety) and one that doesn't affect the great majority of people who use the devices it is placed on.

- Application: The best ways to apply ⏻ (and the other symbols) to future products are described in section 4.

⏻ *Means "Power"*

There is diverse evidence that the average person associates ⏻ and the term "power". Much of this is based on experience in the U.S., but it is likely that it holds true elsewhere in the world as well.

- In the late 1990s, a magazine named "Time Digital" was renamed "ON" magazine and used ⏻ as its logo, clearly indicating that it was to mean "On". The magazine fell victim to the dot-com bust and was discontinued in late 2000.
- The U.S.-based Exelon Corporation was created out of an energy utility merger in 2000. The company chose ⏻ (in green) for the new corporate logo. A representative of their public relations department and a corporate web page (http://www.exeloncorp.com/) both said that the symbol was chosen because it means "Power On".
- In late 2002, the Gateway computer company changed its corporate logo to a sideways version of ⏻, to bring to mind both the "G" of Gateway, and to symbolize power on. In all three of these cases, the companies clearly wanted to communicate the idea of power, activity, and capability, and not passivity and inactivity, which the term "standby" suggests.
- Several office equipment product designers told us that ⏻ was chosen for the power symbol on their products because that is what was on the existing office equipment in their office at the time that design decision was made. Very few product designers have copies of the international standards, or material which reviews their content for power controls.
- Our testing showed that very few people know that the symbol means "standby", and that most think it means "power", "on", or "power on". While the testing was all conducted in the U.S., the results were so dramatic that it seems likely that the same trend holds true elsewhere, even if the difference was not quite so dramatic.
- Most user manuals for office equipment and consumer electronics sold in the U.S. refer to a "power button" and "power indicator" and provide little or no elaboration on this; people know what to expect from these controls. For office equipment, these are most commonly labeled with ⏻. For consumer electronics, the word "power" is common along with ⏻.

As ⏼ means an "on/off" switch, it can also be seen as meaning "power", just as ⏻ is. The confusion between ⏻ and ⏼ is compounded by two further facts. The symbols are often used interchangeably with respect to their meaning (this is particularly confusing on battery-powered devices for which the original reason for the distinction — disconnection from the mains — does not apply). Secondly, the way they are printed often blurs the distinction, with the vertical bar on ⏻ sometimes lowered, the one on ⏼ lengthened, and the circle on ⏻ nearly closed. It is not surprising then that few people distinguish between the symbols in practice.

What to do?

Having two such similar symbols with different meanings seems contrary to good design practice. The standard does not recommend any change to the "on" | and "off" ○ symbols, but these are best used as a pair on rocker (and similar) switches (rather than in isolation or in combination with other symbols). See Section 4 for a discussion of how to apply the symbols on products.

2.4 Power Indicators

A power indicator communicates the power state of the device. The standard provides that the indicator needs to communicate up to three states — *on*, *sleep*, and *off*. For off, almost all consumer devices use an indicator light being off[8]. For *on*, green is clearly the best choice (more on this below). The only major question around power indicators is how to indicate *sleep*. Consideration of design issues and results of the user testing we conducted both suggest steady amber for *sleep*.

For *on*, the power indicator is most commonly green or red (the latter more so on consumer electronics), though the occasional blue or white power indicator can be found. When LEDs first began to be used for power indicators, red was the cheapest and most available color (and most power-efficient, a key consideration for battery-powered devices). Red and orange are also associated with energy and fire, so have some basis as the color for a power indicator. On the other hand, from traffic signal lights and stop signs we associate red with "stop" (see Appendix IV) and indicator standards specify that red is to mean error or warning (see Appendices II and V). Our user testing (see Appendix VII) also found green as a better choice for power than red. From all this, and the already widespread use of green to mean *on* (particularly on office equipment), it is the clear choice.

For *sleep*, while amber is the most common indication, blinking green makes a respectable showing. Legitimate concern about how using green and amber accommodates people who are colorblind is addressed in Appendix IV.

A considerable minority of devices use blinking green for sleep states, or use blinking for other meanings, so the use of this interface device needs serious consideration[9]. Some current devices use blinking for a transition state, e.g. "warming up" (or "waking up") or "cooling down" (as on a projector), but these are of limited time. Some devices use blinking of the power indicator for non-power meaning, such as an error mode, message waiting, network activity, etc.

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[8] A few special devices not for consumer use have an indicator light on to show that the power is being supplied to the device and it is ready to be turned on.

[9] An example of how power states are mapped onto indicator lights comes from the Eizo company (which manufactures monitors under the Nanao brand name) which calls its power management capability "PowerManager". DPMS "Stand-by" (which reduces power only 20% nominally on this brand) results in the indicator remaining green. When the monitor goes onto DPMS Suspend mode (called "PowerManager Mode 1") the indicator blinks green. When it goes into DPMS Off mode (called "PowerManager Mode 2") the indicator turns amber. When the device is actually *off*, the indicator is off.

The key benefit of a blinking green indicator is that it can be implemented with a single (or single color) LED.

The benefits of using steady amber for *sleep* are many. It is consistent with traffic light color usage. It is consistent with indicator light standards (e.g. IEC 73). It is consistent with the colors used in traffic lights, with amber indicating caution or slowness. It allows other uses of blinking. The power state can be assessed instantly rather than require a steady gaze for a few seconds. It is not annoying or calling attention to itself as blinking is to many people in many contexts. It is not dynamic, allowing the color coding for other uses in user interfaces beyond just the indicator light.

An exception to the blinking standard is made for battery-powered products. Some of these presently conserve power by illuminating the power LED only during brief blinks while on and others during sleep modes. If this is used, the standard color assignments (green and amber) should be retained. The brief blinks also distinguish this from the flashing during transitions in which the on and off periods are approximately the same. Blinking indicators for transitions are covered in Section 2.7.

The standard also provides that alternating green and amber can be used to indicate an error when the red color is not available. Some devices use high speed flashing to indicate an error. The alternating colors is a simpler, more distinct way to express the error condition.

Other Indication Mechanisms

Beyond normal LED indicators, some devices use a display (usually LCD) to include the power status by turning the display off when off and displaying “SLEEP” or some other word when in a sleep mode, and / or turning the backlight off. Backlight behavior should be at the discretion of product designers (or even users). The key for displays is to use some combination of the sleep symbol, the word “sleep”, or color associations to communicate that the device is in a *sleep* state.

In principle, a mechanical indicator could be used for the power state. This has some advantages, but is not used at present except as manifested by the mechanical state of some switch positions. Mechanical indicators could be used to indicate the operating system state when the device is off (to be able to distinguish hibernate from other forms of *off*).

2.5 Sleep Metaphor and Symbol

For naming power states, there is no reason to question “on” and “off”, and for low-power modes, “sleep” is the clear choice.

For some devices, it is helpful to distinguish among *on* states by the functional state of the device, through terms such as “ready” or “active”. Variations of *off* can also be helpful, such as soft-off, hard-off, and shutdown (“hibernate” should be a form of *off*, but the term “hibernate” should not be used as it implies a form of *sleep*).

The only real question is how to label the low-power mode. Words used on current and recent devices include: sleep, standby, suspend, energy-saver, low-power, idle, doze, PowerManager Mode, deep sleep, power-saver, ENERGY STAR mode, and conservation mode — but there are others.

For devices in a reduced-capability, low-power state, the ”sleep” metaphor is the most common and clear metaphor used, and is often referred to in manuals even in cases in which other terms (e.g. standby or suspend) are used in the user interface. “Sleep” is the clear choice in terms of the clarity of the metaphor, names for transitions, ease of creating sub-state terms, graphic representation, and ease of translation.

For the competitors to sleep, the idea of “suspending” activity may conjure up a clear idea, but is problematic as some devices (e.g. a printer or copier) have a mode of activity or inactivity that is separate from whether the device is globally awake or asleep. There is also no obvious visual analog to “suspend”, nor is the verbal extensions appealing (“going into suspend”) or obvious (e.g. “resuming” from suspend).

The term “standby” does not seem to reside within a single obvious metaphor, and is problematic due to its many diverse meanings (see Section 3 for more on this).

Another archetype, perhaps less well defined than sleep, is “Ready”. Some copiers and printers have a “ready” indicator to show when they are available to perform their primary function, namely imaging. Some discussions of PC use use the phrases “ready-to-use” or “ready-for-use” (Ease of Use Roundtable, Computer Power Management Questionnaire, 2000). Thus, “not ready” could be used to mean sleep, though this really addresses a functional state rather than a power state.

None of these alternatives remotely challenges the merits of “sleep” as the organizing principle for low-power modes.

The sleep metaphor could be carried too far, such as to imply that a device that is off is “dead”. This does not seem to be a problem with current devices that use the sleep metaphor.

The metaphor manifests itself as: the term “sleep” which can be used on graphic displays to show a low-power mode, and in control panels; the “moon” symbol for buttons that manually put the device into or out of the sleep mode (or, rarely, for a sleep indicator separate from the power indicator); and the phrases and ideas of “waking up” and “going to sleep”.

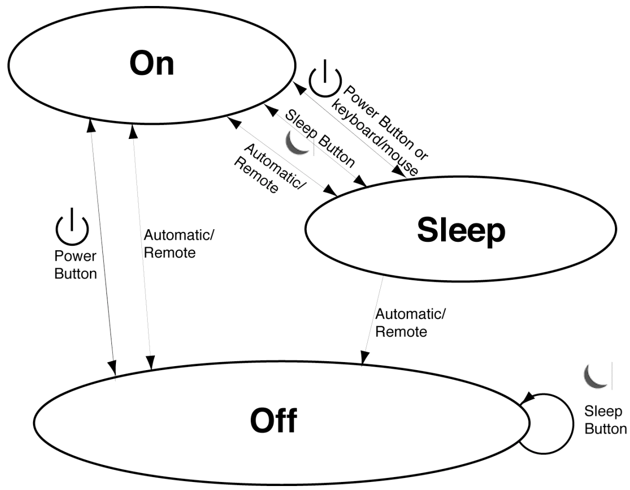
The moon symbol — ☾ — is the most common graphic representation of sleep (though multiple “Zs” (ZZZZZ) are sometimes used). There is no similar symbol on products that it could easily be confused with, and meets the criteria of simplicity for symbol design. Details on this and how the moon is used in the context of Islamic are presented in Appendix VI.

2.6 Transitions

Most of the User Interface Standard covers static power states, but it is also necessary to address how state transitions are initiated, and what behavior is exhibited during them. This topic is also addressed in Section 4.

Figure 1 shows a sample state diagram for a PC. On some PCs, the behavior of power controls such as the power button, sleep button, and lid switch are all programmable, so that not all possible transitions are always available. An example of an automatic transition is one based on a delay timer, a real time clock (e.g. turn on the PC at 8:30 a.m.), or an alarm (e.g. too high of an internal temperature). An example of a remote transition is one initiated by a device elsewhere on the network.

Figure 1. A sample PC state diagram.



Four elements of the dynamic behavior part of the standard have to do with hardware aspects of transitions.

The power button toggles between the two most common power states.

This is to provide for the most common power state changes to be able to be made by the same control, in the way that conventional light switches use the same element for turning on and off. This aids people to use devices without having to think about other controls in most circumstances.

When a device is asleep, pressing the power button will (usually) wake it up.

This is also to provide the power control as a central mechanism to change states. It also can alleviate devices from having to monitor other inputs which may be unavailable in sleep modes or power-intensive to monitor. Exceptions are when an external device is controlling the power status, as a PC does for a monitor.

Holding down a power button for an extended time will trigger an emergency action.

Many devices require some mechanism to reset hardware when the system gets into a problematic state. As the power button is usually the most protected (to avoid accidental pressing), this makes accidental reset unlikely. Also, should there be an emergency such that powering off the device without delay is required, pressing the power button is the most obvious control to do this.

Usually, when a device is asleep, the input causing a wake event should be discarded.

In many cases, the information context of a device is not apparent when the device is *asleep* as the display which shows the context is *off* or *asleep*. Because of this, using the content of the wake event could cause bad consequences, and often the input is simply intended just to cause the wake and nothing else. Some wake events can be executed without problem, such as if a media eject button is the event.

The power indicator is to flash during state transitions. The reasons for this are several: it is usually more important to signal a change of state to the user than it is to signal a long-term stable state; the flashing helps reassure the user that something is happening (it is a simple "progress indicator"); and device behavior may be different during the transition than it is during any of the stable states.

For transitions, the standard also provides for optional audio indications. Devices with motors that spin up and down with their power state provide a model. These range from jet planes to the hard disk drives on PCs. These suggest using a rising tone for a turn-on or wake-up event, and a falling tone for a turn-off or going-to-sleep event. The interval the tone covers could be much larger for the on / off transitions than for the sleep transitions to indicate the magnitude of the change. Everything else about the audio signal could be left to the discretion of the designer, such as time duration, tone intervals, tambre, pitch, etc. Current systems which have a constant tone on boot-up are perhaps connoting an orchestra tuning up indicating a "ready" state, but this doesn't seem to have good analogues for sleep transitions or turn-off.

Sometimes it is advantageous to suppress state transitions. For example, the DPMS Standard [VESA, 1993 recommends that there be a five second delay when a transition from "On" seems apparent – this to avoid inadvertent transitions when changing display resolution and / or timing. In practice this seems to be implemented by having the screen trace all black content and maintain the power indicator green for the five second duration. The DVI specification (DDWG, 1999) similarly states that a display should power down if the data stream ceases for more than five seconds.

3.0 The "Standby" Problem

The most problematic term in the area of power control is "Standby". It is a reliable source of confusion to individuals, and confusion over the meaning of the term between professionals at an industry meeting was the original instigation for the project that created the User Interface Standard.

Terms for power modes stretch back to the dawn of computing, to at least 1951. The first commercially available computer, the UNIVAC, includes a switch on its control panel with one setting both "**`OFF`**" and "**`STAND-BY POWER`**" (see Figure 2). What the switch does, and why "stand-by" was used we do not know. A likely possibility is that this was not a main power switch to cut power to the whole system to zero, but rather was a functionally-off state with auxiliary systems (e.g. the vacuum tube heaters) remaining on.

At the present time, "standby" has a variety of different meanings with respect to electronic devices.

- On a *copier*, "standby" is the mode when the machine is fully powered up and ready to copy (but not actually doing so). This exists on products and in the ASTM measurement standard for energy consumption of copiers.
- On *some computers*, "standby" refers to a low-power mode. Depending on the hardware and software, this can be a relatively small or quite large percentage reduction from the full-on state. Important references for this usage are the DPMS and APM standards, and most versions of the Windows operating system.

Figure 2. A corner of the UNIVAC control panel

Source: Smithsonian Institution, National Museum of American History

- In other contexts, "Standby Power" is the energy used while a device is at its lowest power level or even nominally "off". Important sources for this usage are the Executive Order on Standby Power, the Department of Energy / Federal Energy Management Program efforts in this area, and research on the topic[10].
- The older use of the term "standby" for equipment and people was a statement about its capability to be put into use on short- or no-notice. This is really a statement about functionality which does not map directly onto power states in a clear way.

In each of these cases, the term was first used in technical discussions or documents, and only later migrated to more general usage and into the user interface.

A minor issue is that "standby" is sometimes hyphenated and products and sometimes not, as in international documents. Products and documents of U.S. origin generally do not include hyphenation; those from elsewhere sometimes do.

4.0 Power Switch Labeling

Clearly and unambiguously labeling power switches and buttons for modern electronic devices is becoming increasingly challenging. The international symbols for power control (see Table 1) were established in 1973 with some dating back at least sixty years. At that time, most devices had just two power modes (*on* and *off*), a single mechanical power switch, and zero power consumption in *off*. Today, electronic devices commonly have multiple power modes and

[10] More about these can be found at: http://www.whitehouse.gov/news/releases/2001/07/20010731-10.html — http://www.eere.energy.gov/femp/resources/standby_power.html and http://standby.lbl.gov

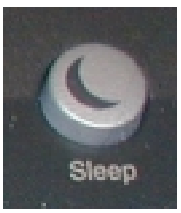
multiple power switches[11]. In addition, many consume "standby" power — non-zero power consumption in the minimum power mode, usually an *off* mode — so that the only way to achieve zero power draw is to pull the plug.

An increasing portion of electronic devices have automatic controls — they can change their power state without user action, in some cases even to turn themselves *on* from an *off* state. Automatic controls and external power supplies are some of the reasons for the increasing use of "soft" switches and buttons that send a signal rather than change power status directly.

The existing vocabulary of symbols is not adequate to clearly and unambiguously capture all the common power control implementations we find on contemporary devices. The two major complicating factors are low-power "*sleep*" modes and non-zero-power *off* modes (consuming "standby power"). Solutions are needed that are as compatible as possible with current product usage, and minimize the disruption to the symbol standards. Consistency and clarity should be the paramount goals, to minimize confusion and errors.

4.1 User Interface Elements

Power Modes/States



Sleep modes are usually entered by means other than a power switch (such as a delay timer), and so are not generally identified by a switch position. When *sleep* does need to be labeled, a crescent moon symbol — ⏾ — should be used (though not yet an IEC symbol). For power switches, the modes indicated by the switch position are generally are *on*, *soft-off* (non-zero power consumption) and *hard-off* (zero power consumption). Indicator lights generally differentiate among *on*, *sleep*, and *off*.

Switches

Switch types commonly found on consumer devices include:

- Rocker switch - 2 state. Switches between *on* and *soft-off* or *on* and *hard-off*. May be movable to *off* by automatic means.
- Rocker switch - 3 state, with *on* a momentary state. The intermediate state of the switch is *on* or automatic *off*.
- Push-button - 2 state, with a mechanically observable difference between the two states. Can be a notebook lid switch; an example of a non-traditional switch format.
- Momentary contact switch — a button or slider. Only one stable state. Moving the switch may cause a transition to the opposite state, or always to *on*.

Symbols

The IEC power control symbols are: | for *on*, ○ for *off*, ⏼ for an *on/off* switch, and ⏻ for "standby". For both ○ and ⏼, safety standards specify that the *off* state is to be a zero-power *off* — *hard off*. This leaves just ⏻ for a multitude of

[11] "Switch" here refers to anything performing the switch function, including buttons, lid switches, etc.

other uses and meanings. There are many examples of devices which use non-IEC symbols for power controls. Needless to say, these create even more different labeling possibilities and opportunities for user confusion.

Indicators

"Power indicators" are usually called just that. They show the power state — *on*, *sleep*, or *off* — and for mechanical switches, *sleep* occurs in the *on* position. They only rarely distinguish between *hard-off* and *soft-off*. Indicators are often simply adjacent to the power switch and not separately labeled; when they are, they are usually labeled with ⏻ or "power".

The ⏻ problem

With clear and precise definitions for I, ○, and ⏼, a multitude of uses have been assigned to the ⏻ symbol on recent products, guaranteeing that some will be in conflict. There is a large body of evidence that the symbol is best understood by people in the U.S. (and probably elsewhere) as meaning "power" (or (or "power-on", or the "on button"). There is no existing symbol that means "power", so the usage of ⏻ as meaning "power" arose out of a clear need. The previous meaning of "standby" may have made sense at the time it was established (decades ago) but is now obsolete. The ⏻ symbol should be used as a substitute for "power" throughout the power control context as for a power button, power indicator, or power control panel.

4.2 Applications of Interface Elements

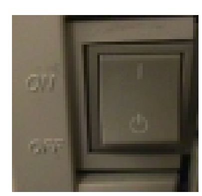
Good Applications

Some common applications are clear with the present symbols. Examples are devices with:

- A rocker switch in which *off* is zero power; it will be labeled with I and ○.
- A push-button 2 state switch in which *off* is zero power; it will be labeled with ⏼
- A push-button or momentary contact switch with non-zero power in *off*; it will be labeled with ⏻.

4.2.1 Applications with problems

Other applications raise ambiguities, inconsistencies, and confusion. These can lead to annoyance, energy waste, and in the medical context, perhaps safety concerns.



Soft-off. Some devices have a rocker switch that toggles between *on* and *soft-off*. When this occurs on office equipment, it usually has I for *on* and ⏻ for *off*. The problem with this is that it identifies ⏻ as meaning *off*, whereas when it is used on a power button, people interpret it as meaning *power* or *on*.

Multiple power switches. Other devices have two power switches: one which controls the functional power state (for which the *off* power level is not important) and the other which is used to switch the device to zero power. User manuals often call the latter a "main power" switch. The question arises as to whether the icon labeling of the two switches should make clear their relationship, or whether cues such as location are always sufficient (e.g. the main power switch being on the back of the device near where the power cord enters). Regardless, if the main power switch goes to zero power on *off*, it should have the | and ◯ symbols.

Unknown *off* power. In some contexts, the power consumption while *off* may not be known or may change. This occurs in operating systems that may not know the power status of the hardware they run on and so may not know which symbol(s) to use. This also can occur with devices that can be operated on battery or mains power; their status while *off* may vary depending on whether the device is mains-connected, and also whether the battery is present[12].

Automatic state changes. Automatic controls can change the power state, which is particularly a concern for transitions to and from *off*. This requires either avoiding switches (like most rockers) that mechanically show the power state, or utilize ones that can be physically moved by the device (some copiers use these).

4.3 Recommendations and Conclusions

The purpose of the standard is to provide a simple set of interface elements that are applied universally on products in a clear and consistent way. In concert with the User Interface Standard, the following recommendations get us closer to that goal.

Create a new symbol for non-zero-power off.

The present set of international standard symbols for power control lacks a workable designation for equipment that are functionally off but continue to draw some power (the ◯ symbol is reserved for zero power). This would solve the problem of a rocker switch with a non-zero off. Unfortunately, at present there are no obvious candidates.

Specify that ⏻ means "power", and use it for power buttons and indicators.

This should be used to mean "power" on power controls — even if a power button goes to a *hard-off*, that should not introduce any safety issue. The symbol standard should be changed, but manufacturers need not wait for that to be finalized before using ⏻ for "power".

Only use rocker switches for power controls when off *is zero power,* and
Use push-button switches for power controls when off *is non-zero power.*

These recommendations get around the lack of a good symbol for soft-off.

Use caution with indicators when multiple power switches are used.

When a device has two power controls, or otherwise has a *hard-off* and *soft-off* mode, both will have the power indicator off. Only inspection or manipulation of the power switches will clarify which mode it is in. To avoid ambiguity, some devices have more than one power

[12] UPS (uninterruptible power supply) systems might also introduce similar ambiguity.

indicator to get around this, and some use a different color (e.g. red) to indicate *soft-off*, but both of these solutions are potentially confusing.

Use hard-off switches when possible.

Hard-off switches — labeled with ⭘ or ⏼ — have the advantage of eliminating “standby power”.