

Universal Serial Bus (USB)

Device Class Definition for Human Interface Devices (HID)

Firmware Specification—Released: June-96

Version 1.0

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1. Preface

1.1 Intellectual Property Disclaimer

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1.3 Scope of this Revision

This version 1.0 release is intended to encapsulate all review comments and concepts to complete the Human Interface Device (**HID**) device class.

1.4 Revision History

Version	Release date	Description
0.9d	2/1/96	Draft for industry review (USB_HI9D.DOC).
0.9e	3/15/96	Revised tag values and device requests. Added constant, long items, designators and descriptor examples (USB_HI9E.DOC).
0.99a	4/22/96	Revised requests and unit tag. Added appendices for BNF example, usage codes and keyboard implementation details (USB_H99a.DOC).
1.0	6/14/96	Finalized terminology, updated examples, incorporated final review comments (USB_H10.DOC).

1.5 Document Conventions

This specification uses the following typographic conventions

Example of convention	Description
Get_Report, Report	Words in bold with initial letter capitalized indicate elements with special meaning such as requests, descriptors, descriptor sets, classes, or subclasses.
Data, Non-Data	Proper-cased words are used to distinguish types or categories of things. For example Data and Non-Data type Main items.
<i>BValue</i>	Italicized letters or words indicate placeholders for information you supply.
<i>bValue, bcdName, wOther</i>	Placeholder prefixes such as ‘ <i>b</i> ’, ‘ <i>bcd</i> ’, and ‘ <i>w</i> ’ are used to denote placeholder type. For example: <i>b</i> bits or bytes; dependent on context <i>bcd</i> binary-coded decimal <i>bm</i> bitmap <i>d</i> descriptor <i>i</i> index <i>w</i> word
[<i>bValue</i>]	Items inside square brackets are optional.
...	Ellipses in syntax, code, or samples indicate ‘and so on...’ where additional optional items may be included (defined by the developer).
{this (0) that (1)}	Braces and a vertical bar indicate a choice between two or more items or associated values.
Collection End Collection	This font is used for code, pseudo-code, and samples.

2. Introduction

Universal Serial Bus (USB) is a communications architecture that gives a personal computer (PC) the ability to interconnect a variety of devices using a simple four-wire cable. The USB is actually a two-wire serial communication link that runs at either 1.5 or 12 megabits per second (mbs). USB protocols can configure devices at startup or when they are plugged in at run time. These devices are broken into various device classes. Each device class defines the common behavior and protocols for devices that serve similar functions. Some examples of USB device classes are shown in the following table.

Device Class	Example Device
Display	Monitor
Communication	Modem
Audio	Speakers
Mass storage	Hard drive
Human interface	Data glove

See Also

For more information on terms and terminology, see Appendix H: Glossary Definitions. The rest of this document assumes you have read and understood the terminology defined in the glossary.

2.1 Scope

This document describes the Human Interface Device (**HID**) class for use with Universal Serial Bus (USB). Concepts from the USB Specification are used but not explained in this document.

See Also

The USB Specification is recommended pre-reading for understanding the content of this document. For related document locations, see Section 2.3: Related Documents.

The **HID** class consists primarily of devices that are used by humans to control the operation of computer systems. Typical examples of **HID** class devices include:

- Keyboards and pointing devices—for example, standard mouse devices, trackballs, and joysticks.
- Front-panel controls—for example: knobs, switches, buttons, and sliders.
- Controls that might be found on devices such as telephones, VCR remote controls, games or simulation devices—for example: data gloves, throttles, steering wheels, and rudder pedals.
- Devices that may not require human interaction but provide data in a similar format to **HID** class devices—for example, bar-code readers, thermometers, or voltmeters.

Many typical **HID** class devices include indicators, specialized displays, audio feedback, and force or tactile feedback. Therefore, the **HID** class definition includes support for various types of output directed to the end user.

Note Force feedback devices requiring real time interaction are covered in a separate document titled “USB Physical Interface Device (PID) Class.”

See Also

For more conceptual information, see the USB Specification, Chapter 9, “USB Device Framework..” For related document locations, see Section 2.3: Related Documents.

2.2 Purpose

This document is intended to supplement the USB Specification and provide **HID** manufacturers with information necessary to build USB-compatible devices. It also specifies how the **HID** class driver should extract data from USB devices. The primary and underlying goals of the **HID** class definition are to:

- Be as compact as possible to save device data space.
- Allow easy extensions.
- Allow the software application to skip unknown information.
- Be extensible and robust.
- Support nesting and collections.
- Be self-describing to allow generic software applications.

2.3 Related Documents

This document references the following related documents. The most current information is maintained in the following locations on the World Wide Web.

Name	Location	Comment
Universal Serial Bus (USB) Specification, Version 1.0	http://www.teleport.com/~usb/specinfo.htm	In particular, see Chapter 9, “USB Device Framework.”
USB Class Specification for Legacy Software	http://www.teleport.com/~usb/	
HID Usage Tags	http://www.teleport.com/~usb/	
USB Physical Interface Device (PID) Specification	http://www.teleport.com/~usb/devclass.htm	
USB Audio Device Class	http://www.teleport.com/~usb/devclass.htm	

3. Management Overview

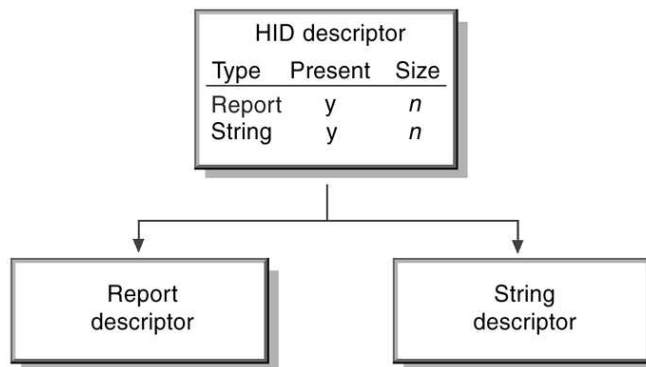
Information about a USB device is stored in segments of its ROM (read-only memory). These segments are called descriptors. An interface descriptor can identify a device as belonging to one of a finite number of classes. The **HID** class is the primary focus of this document.

A USB/HID class device uses a corresponding **HID** class driver to retrieve and route all data.

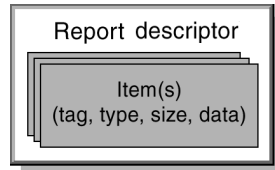
The routing and retrieval of data is accomplished by examining the descriptors of the device and the data it provides.



The **HID** class device descriptor identifies which other descriptors are present and indicates their sizes. For example, **Report** and **String**. Descriptors.



A **Report** descriptor describes each piece of data that the device generates and what the data is actually measuring.

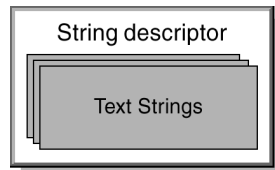


For example, a **Report** descriptor defines items that describe a position or button state. Item information is used to:

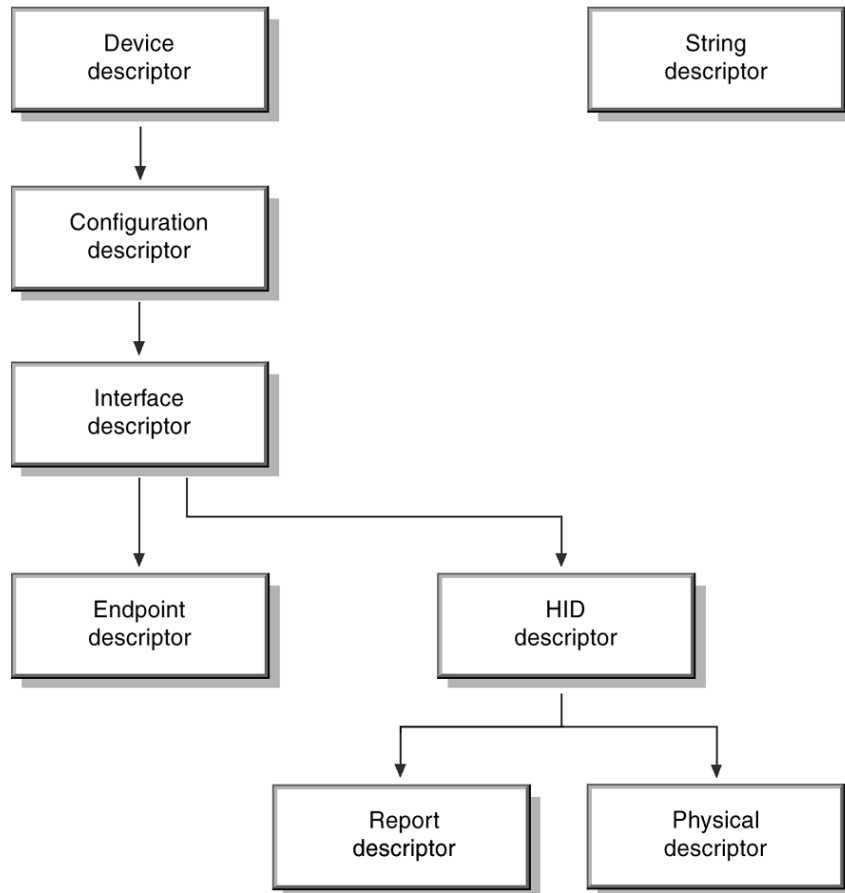
- Determine where to route input—for example, send input to mouse or joystick API.
- Allow software to assign functionality to input—for example, use joystick input to position a tank.

By examining an items (collectively called the **Report** descriptor) the **HID** class driver is able to determine the size and composition of data reports from the **HID** class device.

String descriptors allow the device to associate a text string with a particular control—for example, “trigger.”



All of these things can be combined to illustrate the descriptor structure.



The rest of this specification documents implementation details, caveats, and restrictions for developing **HID** class devices and drivers.

4. Functional Characteristics

This Section describes the functional characteristics of the **HID**:

- Class
- Subclass
- Interfaces

4.1 The HID Class

USB devices are segmented into device classes that:

- Have similar data transport requirements.
- Share a single class driver.

For example, **Audio** class devices require isochronous data pipes. **HID** class devices have different (and much simpler) transport requirements. The transport requirements for **HID** class devices are identified in this document.

Note USB devices with data requirements outside the range of defined classes must provide their own class specifications and drivers as defined by the USB Specification. For related document locations, see Section 2.3: Related Documents.

A USB device may be a single class type or it may be composed of multiple classes. For example, a telephone hand set might use features of the **HID**, **Audio**, and **Telephony** classes. This is possible because the class is specified in the **Interface** descriptor and not the **Device** descriptor. This is discussed further in Section 5.1: Device Descriptor Structure.

See Also

The Audio Class Specification defines audio device transport requirements in greater detail. For related document locations, see Section 2.3: Related Documents.

4.2 Subclass

During the early development of the **HID** specification, subclasses were intended to be used to identify the specific protocols of different types of **HID** class devices. While this mirrors the model currently in use by the industry (all devices use protocols defined by similar popular devices), it quickly became apparent that this approach was too restrictive. That is, devices would need to fit into narrowly defined subclasses and would not be able to provide any functionality beyond that supported by the subclass.

The **HID** committee agreed on the improbability that subclass protocols for all possible (and yet to be conceived) devices could be defined. In addition, many known devices seemed to straddle multiple classifications—for example, keyboards with locators, or locators that provided keystrokes. Consequently, the **HID** class does not use subclasses to define most protocols. Instead, a **HID** class device identifies its data protocol and the type of data provided within its **Report** descriptor.

The **Report** descriptor is loaded and parsed by the **HID** class driver as soon as the device is detected. Protocols for existing and new devices are created by mixing data types within the **Report** descriptor.

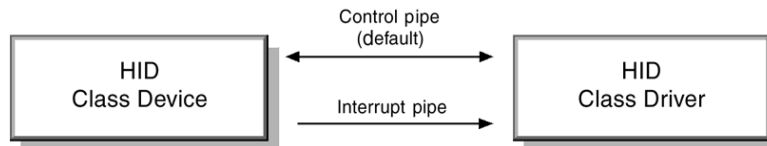
Note Because the parser for the **Report** descriptor represents a significant amount of code, a simpler method is needed to identify the device protocol for devices requiring BIOS support (boot devices). **HID** class devices use the **Subclass** part to indicate devices that support a predefined protocol for either mouse devices or keyboards (that is, the device can be used as a boot device). The boot protocol can be extended to include additional data not recognized by the BIOS, or the device may support a second preferred protocol for use by the **HID** class driver.

See Also

Boot **Report** descriptors are listed in Appendix B: Boot Interface Descriptors. For **HID** subclass and protocol codes, see Appendix E: Example USB Descriptors for **HID** Class Devices.

4.3 Interfaces

A **HID** class device communicates with the **HID** class driver using either the **Control** (default) pipe or the **Interrupt** pipe.



The **Control** pipe is used for:

- Receiving and responding to requests for USB control and class data.
- Transmitting data when polled by the **HID** class driver (using the **Get_Report** request).
- Receiving data from the host.

The **Interrupt** pipe is used for:

- Transmitting asynchronous (unrequested) data.

Note **Endpoint 0** is a **Control** pipe always present in USB devices. Therefore, only the **Interrupt** pipe is described for the **Interface** descriptor using an **Endpoint** descriptor. In fact, several **Interface** descriptors may share **Endpoint 0**.

Pipe	Description	Required
Control (Endpoint 0)	USB control, class request codes, and polled data (Message data).	Y
Interrupt	Data in, that is, data from device (Stream data).	Y

See Also

For details about the **Control** pipe, see the USB Specification. For related document locations, see Section 2.3: Related Documents.

4.4 Device Limitations

This specification applies to both high-speed and low-speed **HID** class devices. Each type of device possesses various limitations.

4.4.1 Low-Speed Device Limitations

Low-speed devices have the following limitations:

- Transaction size is a maximum of 8 bytes per frame (1 millisecond).
- Only one low-speed transaction is permitted per frame (this limits the number of low-speed devices permitted on the bus).
- Hubs cannot be low-speed.
- Polling rate is defined at a maximum of every 8 milliseconds.
- The size of a request should be minimized as much as possible (with an upper limit of 8 bytes for common transfers) because low-speed **Control** pipes are limited to one (8 byte) transaction every eight frames.

4.4.2 High-Speed Device Limitations

High-speed devices have the following limitations:

- Transaction size is a maximum of 64 bytes per frame (1 millisecond).
- Polling rate is defined at a maximum of every 1 millisecond.

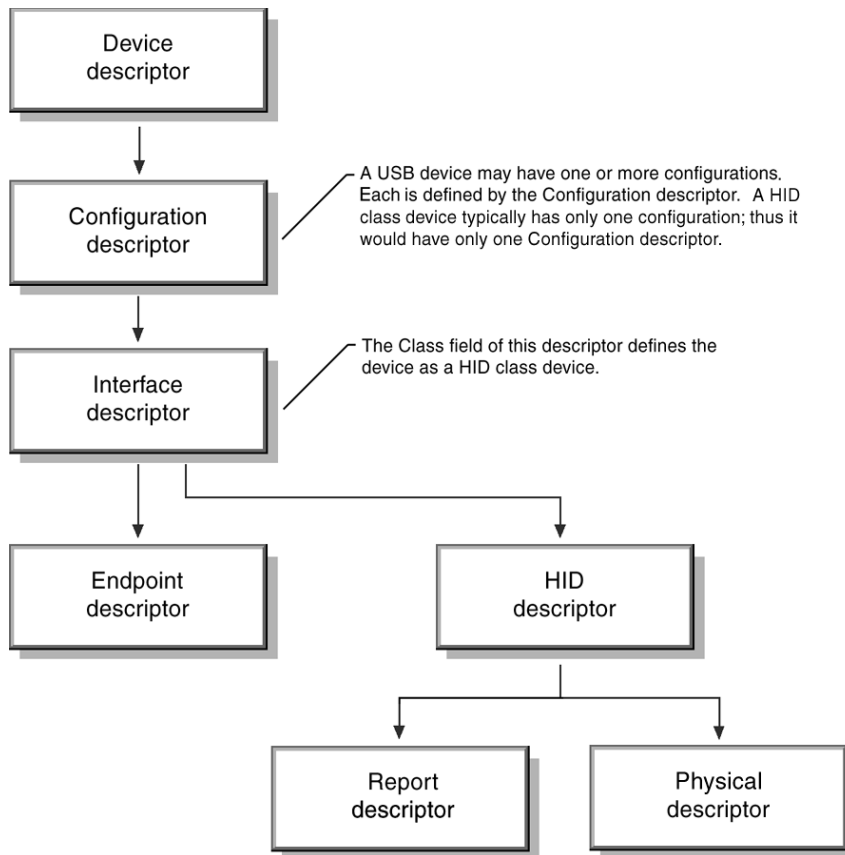
5. Operational Model

This section outlines the basic operational model of a **HID** class device. Flowchart elements represent tables of information with the firmware.

5.1 Device Descriptor Structure

At the topmost level, a descriptor includes two tables of information referred to as the Device descriptor and the String descriptor. A standard USB Device descriptor specifies the Product ID and other information about the device. For example, Device descriptor fields primarily include:

- Class
- SubClass
- Vendor
- Product
- Version



For HID class devices, the:

- Class type is not defined at the **Device** descriptor level. The class type for a HID class device is defined by the Interface descriptor.
- Subclass field is used to identify boot devices.

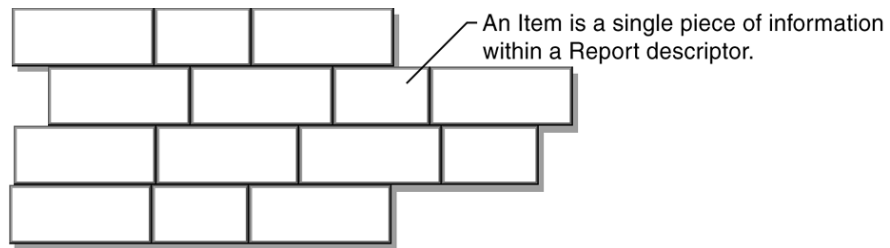
Note Device Class and Device SubClass should not be used to identify a device as belonging to the HID class. Instead use the Interface Class and Interface SubClass fields in the Interface descriptor.

See Also

The HID class driver identifies the exact type of device and features by examining additional class-specific descriptors. For more information, see Section 6.2: Class-Specific Descriptors.

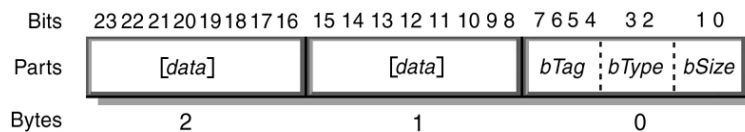
5.2 Report Descriptors

Preceding descriptors are illustrated by flowchart items that represent tables of information. Each table of information can be thought of as a block of data. Instead of a block of data, **Report** descriptors are composed of pieces of information. Each piece of information is called an **Item**.

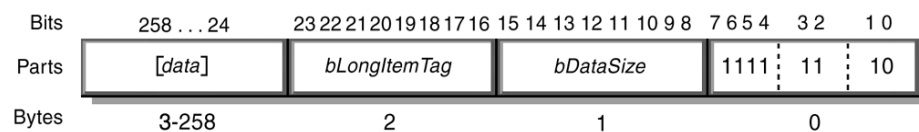


5.3 Generic Item Format

An item is piece of information about the device. All items have a one-byte prefix that contains the item tag, item type, and item size.



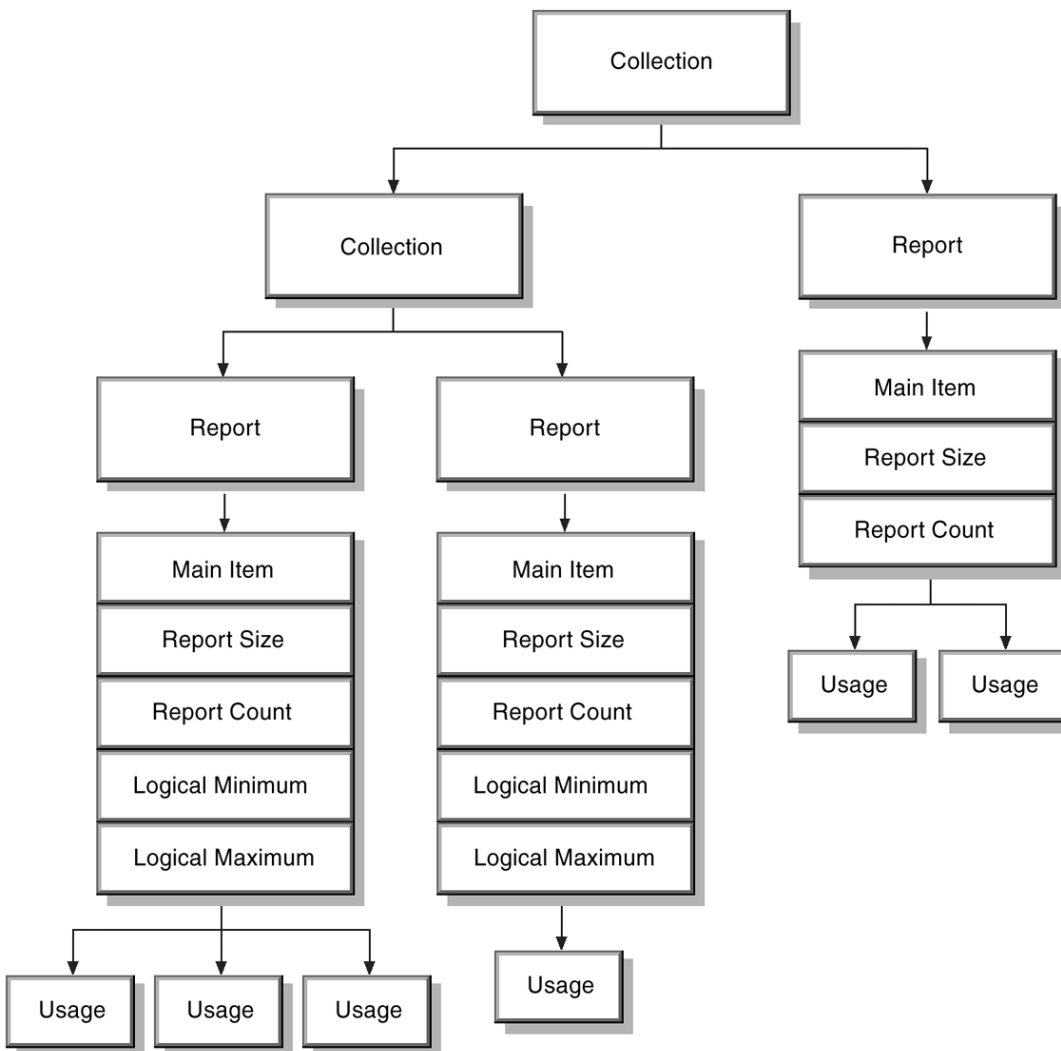
An item may include optional item data. The size of the data portion of an item is determined by its fundamental type. There are two basic types of items: short items and long items. If the item is a short item, its optional data size may be 0, 1, 2, or 4 bytes. If the item is a long item, its *bSize* value is always 2. The following example illustrates possible values within the 1-byte prefix for a long item.



5.4 Item Parser

The **HID** class driver contains a parser used to analyze items found in the **Report** descriptor. The parser extracts information from the descriptor in a linear fashion. The parser collects the state of each known item as it walks through the descriptor, and stores them in an item state table. The item state table contains the state of individual items.

From the parser's point of view, a **HID** class device looks like the following figure.



When some items are encountered, the contents of the item state table are moved. These items include all **Main**, **Push**, and **Pop** items.

- When a **Main** item is found, a new report structure is allocated and initialized with the current item state table. All **Local** items are then removed from the item state table, but **Global** items remain. In this way, **Global** items set the default value for subsequent new **Main** items. A device with several similar controls—for example, six axes—would need to define the **Global** items only once prior to the first **Main** item.

Note **Main** items are associated with a collection by the order in which they are declared. A new collection starts when the parser reaches a **Collection** item. The item parser associates with a collection all **Main** items defined between the **Collection** item and the next **End Collection** item.

- When a **Push** item is encountered, the item state table is copied and placed on a stack for later retrieval.
- When a **Pop** item is found, the item state table is replaced with the top table from the stack. For example:

```
Unit (Meter), Unit Exponent (-3), Push, Unit Exponent (0)
```

When the parser reaches a **Push** item, it places the items defining units of millimeters (meters⁻³) on the stack. The next item changes the item state table to units of meters (meters⁰).

The parser is required to parse through the whole **Report** descriptor to find all **Main** items. This is necessary in order to analyze reports sent by the device.

Note Unrecognized items are passed over by the parser. This allows extensibility of items for future **HID** versions.

See Also

For details, see Section 8: Report Protocol.

5.5 Usages

Usages are part of the **Report** descriptor and supply an application developer with information about what a control is actually measuring. In addition, a **Usage** tag indicates the vendor's suggested use for a specific control or group of controls. While **Report** descriptors describe the format of the data—for example, three 8-bit fields—a **Usage** tag defines what should be done with the data—for example, x, y, and z input. This feature allows a vendor to ensure that the user sees consistent function assignments to controls across applications.

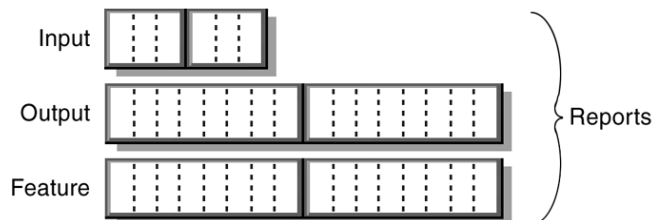
A **Report** descriptor can have multiple **Usage** tags. There is a one-to-one correspondence between usages and controls, one usage control defined in the descriptor. An array indicates that each field of a **Report** descriptor represents several physical controls. Each control may have attributes such as a usage assigned to it. For example, an array of four buttons could have a unique **Usage** tag for each button.

See Also

For an example, see Appendix E. 10: Report Descriptor (Mouse).

5.6 Reports

Using USB terminology, a device may send or receive a transaction every USB frame (1 millisecond). A transaction may be made up of multiple packets (token, data, handshake) but is limited in size to 8 bytes for low-speed devices and 64 bytes for high-speed devices. A transfer is one or more transactions creating a set of data that is meaningful to the device—for example, **Input**, **Output**, and **Feature** reports. In this document, a transfer is synonymous with a report.



Most devices generate reports, or transfers, by returning a structure in which each data field is sequentially represented. However, some devices may have multiple report structures on a single endpoint, each representing only a few data fields. For example, a keyboard with an integrated pointing device could independently report “key press” data and “pointing” data over the same endpoint. **Report ID** items are used to indicate which data fields are represented in each report structure. A **Report ID** item tag assigns a 1-byte identification prefix to each report transfer. If no **Report ID** item tags are present in the **Report** descriptor, it can be assumed that only one **Input**, **Output**, and **Feature** report structure exists and together they represent all of the device’s data.

Note Only **Input** reports are sent via the **Interrupt** pipe. **Feature** and **Output** reports must be initiated by the host via the **Control** pipe.

If a device has multiple report structures, all data transfers start with a 1-byte identifier prefix that indicates which report structure applies to the transfer. This allows the class driver to distinguish incoming pointer data from keyboard data by examining the transfer prefix.

5.7 Strings

A collection or data field can have a particular label (string index) associated with it. Strings are optional.

The **Usage** tag of an item is not necessarily the same as a string associated with the **Main** item. However, strings may be useful when a vendor-defined usage is required. The **String** descriptor contains a list of text strings for the device.

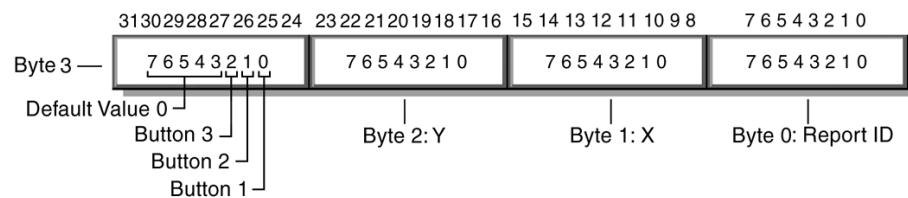
See Also

For details, see Appendix E: Example USB Descriptors for **HID** Class Devices.

5.8 Format of Multibyte Numeric Values

Multibyte numeric values are represented in little-endian format, with the least significant byte at the lowest address. Except where noted otherwise, all integer values are signed values represented in 2's complement format. Floating point values are not allowed.

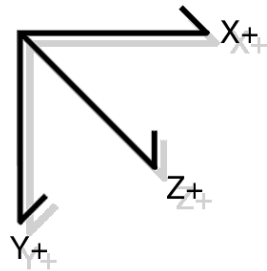
The least significant bit in a value is stored in bit 0, the next more significant in bit 1 and so on up to the size of the value. The following example illustrates bit representation of a long integer value.



Byte	Bits
0	0-7
1	8-15
2	16-23
3	24-31

5.9 Orientation

HID class devices are encouraged, where possible, to use a right-handed coordinate system. If a user is facing a device, report values should increase as controls are moved from left to right (X), from far to near (Y) and from high to low (Z).



Controls reporting binary data should use the convention 0 = off, or False and 1 = on or True. Examples of such controls are keys, buttons, power switches, and device proximity sensors.

6. Descriptors

6.1 Standard Descriptors

The **HID** class device class uses the following standard USB descriptors:

- **Device**
- **Configuration**
- **Interface**
- **Endpoint**
- **String**

See Also

For details about these descriptors as defined for a **HID** class device, see Appendix E: Example USB Descriptors for **HID** Class Devices. For general information about standard USB descriptors, see Chapter 9 of the USB Specification, “USB Device Framework.”

6.2 Class-Specific Descriptors

Each device class includes one or more class-specific descriptors. These descriptors differ from standard USB descriptors. A **HID** class device uses the following class-specific descriptors:

- **HID**
- **Report**
- **Physical**

6.2.1 HID Descriptor

Description

The **HID** descriptor identifies the length and type of subordinate descriptors for a device.

Parts

Part	Offset/Size (Bytes)	Description
<i>bLength</i>	0/1	Numeric expression that is the total size of the HID descriptor.
<i>bType</i>	1/1	Constant name specifying type of HID descriptor.
<i>bcdHID</i>	2/2	Numeric expression identifying the HID Class Specification release.

Part	Offset/Size (Bytes)	Description
<i>bCountry</i>	4/1	Numeric expression identifying country code of the localized hardware.
<i>bAvailable</i>	5/1	Numeric expression specifying the number of class descriptors (always at least one i.e. Report descriptor.)
<i>bType</i>	6/1	Constant name identifying type of class descriptor. See Section 7.1.2: Set_Descriptor Request for a table of class descriptor constants.
<i>wLength</i>	7/2	Numeric expression that is the total size of the Report descriptor.
[<i>bType</i>]...	9/1	Constant name specifying type of optional descriptor.
[<i>bLength</i>]..	10/2	Numeric expression that is the total size of the optional descriptor.

Remarks

- If an optional descriptor is specified, a corresponding length entry must also be specified.
- Multiple optional descriptors and associated lengths may be specified up to offset $(3*n)+6$ and $(3*n)+7$ respectively.
- The value *bAvailable* identifies the number of additional class specific descriptors present. This number must be at least one (1) as a **Report** descriptor will always follow. The remainder of the **HID** descriptor has the length and type of each additional class descriptor.
- The value *bCountry* identifies which country the hardware is localized for. Most hardware is not localized and thus this value would be zero (0). However, keyboards may use the field to indicate the language of the key caps. Devices are not required to place a value other than zero in this field, but some operating environments may require this information. The following table specifies the valid country codes.

Code (dec)	Country	Code (dec)	Country
00	Not Supported	18	Netherlands/Dutch
01	Arabic	19	Norwegian
02	Belgian	20	Persian (Farsi)
03	Canadian-Bilingual	21	Poland
04	Canadian-French	22	Portuguese
05	Czech Republic	23	Russia
06	Danish	24	Slovakia
07	Finnish	25	Spanish
08	French	26	Swedish
09	German	27	Swiss/French

Code (dec)	Country	Code (dec)	Country
10	Greek	28	Swiss/German
11	Hebrew	29	Switzerland
12	Hungary	30	Taiwan
13	International (ISO)	31	Turkish
14	Italian	32	UK
15	Japan (Katakana)	33	US
16	Korean	34	Yugoslavia
17	Latin American	35-255	Reserved

6.2.2 Report Descriptor

The **Report** descriptor is unlike other descriptors in that it is not simply a table of values. The length and content of a **Report** descriptor vary depending on the number of data fields required for the device's report or reports. The **Report** descriptor is made up of items that provide information about the device. The first part of an item contains three fields: item type, item tag, and item size. Together these fields identify the kind of information the item provides.

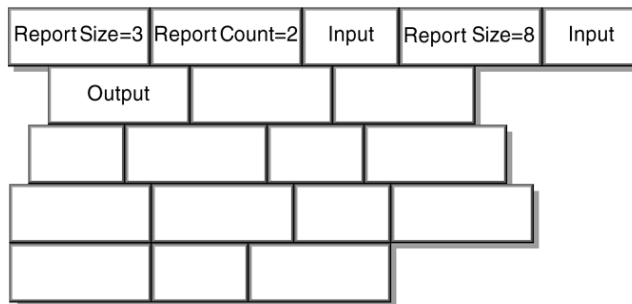
There are three item types: **Main**, **Global**, and **Local**. There are five **Main** item tags currently defined:

- **Input** item tag: Refers to the data from one or more similar controls on a device. For example, variable data such as reading the position of a single axis or a group of levers or array data such as one or more push buttons or switches.
- **Output** item tag: Refers to the data to one or more similar controls on a device such as setting the position of a single axis or a group of levers (variable data). Or, it can represent data to one or more LEDs (array data).
- **Feature** item tag: Describes device input and output not intended for consumption by the end user—for example, a software feature or Control Panel toggle.
- **Collection** item tag: A meaningful grouping of **Input**, **Output**, and **Feature** items—for example, mouse, keyboard, joystick, and pointer.
- **End Collection** item tag: A terminating item used to specify the end of a collection of items.

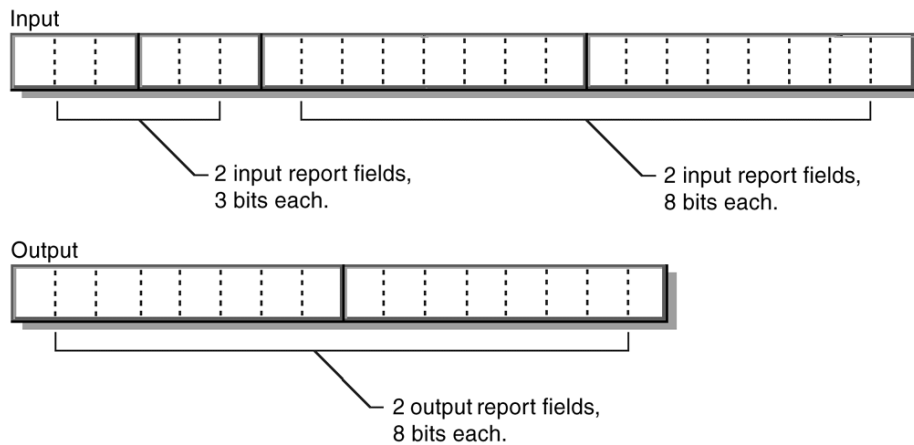
The **Report** descriptor provides a description of the data provided by each control in a device. Each **Main** item tag (**Input**, **Output**, or **Feature**) identifies the size of the data returned by a particular control, and identifies whether the data is absolute or relative, and other pertinent information. Preceding **Local** and **Global** items define the minimum and maximum data values, and so forth. A **Report** descriptor is the complete set of all items for a device. By looking at a **Report** descriptor

alone, an application knows how to handle incoming data, as well as what the data could be used for.

One or more fields of data from controls are defined by a **Main** item and further described by the preceding **Global** and **Local** items. **Local** items only describe the data fields defined by the next **Main** item. **Global** items become the default attributes for all subsequent data fields in that descriptor. For example, consider the following.



The item parser interprets the **Report** descriptor items above and creates the following reports.



A **Report** descriptor may contain several **Main** items. A **Report** descriptor must include each of the following items to describe a control's data (all other items are optional):

- **Input (Output or Feature)**
- **Usage**
- **Usage Page**
- **Logical Minimum**
- **Logical Maximum**
- **Report Size**
- **Report Count**

The following is a coding sample of items being used to define a 3-button mouse. In this case, **Main** items are preceded by **Global** items like **Usage**, **Report Count** or **Report Size** (each line is a new item).

```
Usage Page (Generic Desktop),           ;Use the Generic Desktop Usage Page
Usage (Mouse),
  Collection (Application),             ;Start Mouse collection
  Usage (Pointer),
  Collection (Linked),                  ;Start Pointer collection
  Usage Page (Buttons)
  Usage Minimum (1),
  Usage Maximum (3),
  Logical Minimum (0),
  Logical Maximum (1),                 ;Fields return values from 0 to 1
  Report Count (3),
  Report Size (1),                      ;Create three 1 bit fields (button 1, 2, & 3)
  Input (Data, Variable, Absolute),     ;Add fields to the input report.
  Report Count (1),
  Report Size (5),                      ;Create 5 bit constant field
  Input (Constant),                    ;Add field to the input report
  Usage Page (Generic Desktop),
  Usage (X),
  Usage (Y),
  Logical Minimum (-127),
  Logical Maximum (127),               ;Fields return values from -127 to 127
  Report Size (8),
  Report Count (2),                     ;Create two 8 bit fields (X & Y position)
  Input (Data, Variable, Relative),     ;Add fields to the input report
End Collection,                          ;Close Pointer collection
End Collection                           ;Close Mouse collection
```


<i>bType</i>	Numeric expression identifying type of item where: 0 = Main 1 = Global 2 = Local 3 = Reserved
<i>bTag</i>	Numeric expression specifying the function of the item.
[<i>data</i>]	Optional data.

Remarks

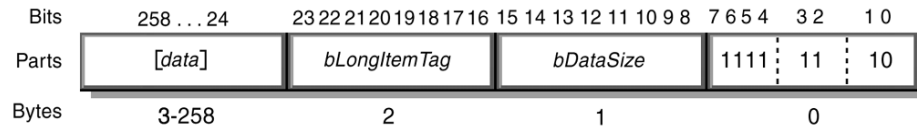
- A short item tag doesn't have an explicit value for *bSize* associated with it. Instead, the value of the item data part determines the size of the item. That is, if the item data can be represented in one byte, then the *data* part can be specified as 1 byte, although this is not required.
- If a large data item is expected, it can still be abbreviated if all of its high-order bits are zero. For example, a 32-bit part in which bytes 1, 2, and 3 are all 0 can be abbreviated as a single byte.
- There are three categories of short item tags: **Main**, **Global**, and **Local**. The item type (*bType*) specifies the tag category and consequently the item's behavior.

6.2.2.3 Long items

Description

Like the short item format, the long item format packs the item size, type, and tag into the first byte. The long item format uses a special item tag value to indicate that it is a long item. The long item size and long item tag are each 8-bit quantities. The item data may contain up to 255 bytes of data.

Parts



Part	Description
<i>bSize</i>	Numeric expression specifying total size of item where size is 10 (2 bytes); denotes item type as long.
<i>bType</i>	Numeric expression identifying type of item where 3 = Reserved
<i>bTag</i>	Numeric expression specifying the function of the item; always 1111.
[<i>bDataSize</i>]	Size of long item data.
[<i>bLongItemTag</i>]	Long item tag.
[<i>data</i>]	Optional data items.

Important No long item tags are defined in this document. These tags are reserved for future use. Tags xF0–xFF are vendor defined.

6.2.2.4 Main Items

Description

Main items are used to either define or group certain types of data fields within a **Report** descriptor. There are two types of **Main** items: data and non-data. Data-type **Main** items are used to create a field within a report and include **Input**, **Output**, and **Feature**. Other items do not create fields and are subsequently referred to as non-data **Main** items.

Parts

Main item tag	One-Byte Prefix (<i>nn</i> represents size value)	Valid Data	
Input	10000 <i>nn</i>	Bit 0	{Data (0) Constant (1)}
		Bit 1	{Array (0) Variable (1)}
		Bit 2	{Absolute (0) Relative (1)}
		Bit 3	{No Wrap (0) Wrap (1)}
		Bit 4	{Linear (0) Non Linear (1)}
		Bit 5	{Preferred State (0) No Preferred (1)}
		Bit 6	{Null state (0) No Null position (1)}
		Bit 7	Reserved (0)
		Bit 8	{Bit Field (0) Buffered Bytes (1)}
		Bit 31-9	Reserved (0)
Output	100100 <i>nn</i>	Bit 0	{Data (0) Constant (1)}
		Bit 1	{Array (0) Variable (1)}
		Bit 2	{Absolute (0) Relative (1)}
		Bit 3	{No Wrap (0) Wrap (1)}
		Bit 4	{Linear (0) Non Linear (1)}
		Bit 5	{Preferred State (0) No Preferred (1)}
		Bit 6	{Null state (0) No Null position (1)}
		Bit 7	{Non Volatile (0) Volatile (1)}
		Bit 8	{Bit Field (0) Buffered Bytes (1)}
		Bit 31-9	Reserved (0)
Feature	101100 <i>nn</i>	Bit 0	{Data (0) Constant (1)}
		Bit 1	{Array (0) Variable (1)}
		Bit 2	{Absolute (0) Relative (1)}
		Bit 3	{No Wrap (0) Wrap (1)}
		Bit 4	{Linear (0) Non Linear (1)}
		Bit 5	{Preferred State (0) No Preferred (1)}
		Bit 6	{Null state (0) No Null position (1)}
		Bit 7	{Non Volatile (0) Volatile (1)}
		Bit 8	{Bit Field (0) Buffered Bytes (1)}
		Bit 31-9	Reserved (0)

Main item tag	One-Byte Prefix (<i>nn</i> represents size value)	Valid Data	
Collection	101000 <i>nn</i>	0x00	Linked (group of axes)
		0x01	Application (mouse, keyboard)
		0x02	DataLink (interrelated data)
		0x03-0x7F	Reserved
		0x80-0xFF	Vendor-defined
End Collection	110000 <i>nn</i>	Not applicable. Closes an item collection.	
Reserved	110100 <i>nn</i> to 111100 <i>nn</i>	Not applicable. Reserved for future items.	

Remarks

- The default data value for all **Main** items is zero (0).
- An **Input** item could have a data size of zero (0) bytes. In this case the value of each data bit for the item can be assumed to be zero. This is functionally identical to using a item tag that specifies a 4-byte data item followed by four zero bytes.

6.2.2.5 Input, Output, and Feature Items**Description**

Input, **Output**, and **Feature** items are used to create data fields within a report.

- An **Input** item describes information about the data provided by one or more physical controls. An application can use this information to interpret the data provided by the device. All data fields defined in a single item share an identical data format.
- The **Output** item is used to define an output data field in a report. This item is similar to an **Input** item except it describes data sent to the device—for example, LED states.
- **Feature** items describe device configuration information that can be sent to the device.

Parts

Bit	Part	Value	Description
0	Data Constant	0 1	Indicates whether the item is data or a constant value. Reports can be padded with constants to byte-align fields. Data indicates the item is defining report fields that contain device data. Constant indicates the item is adding a field of bits simply to pad the report.

Bit	Part	Value	Description
1	Array Variable	0 1	<p>Indicates whether the item creates variable or array data fields in reports. In variable fields, each field represents data from a physical control. The number of bits reserved for each field is determined by preceding Report Size/Report Count items. For example, a bank of eight on/off switches could be reported in 1 byte declared by a variable Input item where each bit represents one switch, on (1) or off (0) (Report Size = 1, Report Count = 8). Alternatively, a variable Input item could add 1 report byte used to represent the state of four three-position buttons, where the state of each button is represented by two bits (Report Size = 2, Report Count = 4). Or 1 byte from a variable Input item could represent the x position of a joystick (Report Size = 8, Report Count = 1).</p> <p>An array provides an alternate means for describing the data returned from a group of buttons. Arrays are more efficient, if less flexible than variable items. Rather than returning a single bit for each button in the group, an array returns an index in each field that corresponds to the pressed button (like keyboard scan codes). An array field will return a 0 value when no controls in the array are pressed. Buttons or keys in an array that are simultaneously pressed need to be reported in multiple fields. Therefore, the number of fields in an array input item (Report Count) dictates the maximum number of simultaneous controls that can be reported. A keyboard could report up to three simultaneous keys using an array with three 8-bit fields (Report Size = 8, Report Count = 3). Logical Minimum specifies the lowest index value returned by the array and Logical Maximum specifies the largest. The number of elements in the array can be deduced by examining the difference between Logical Minimum and Logical Maximum (number of elements = Logical Maximum - Logical Minimum).</p>
2	Absolute Relative	0 1	<p>Indicates whether the data is absolute (based on a fixed origin) or relative (indicating the change in value from the last report). Mouse devices usually provide relative data, while tablets usually provide absolute data.</p>

Bit	Part	Value	Description
3	No Wrap Wrap	0 1	Indicates whether the data “rolls over” when reaching either the extreme high or low value. For example, a dial that can spin freely 360 degrees might output values from 0 to 10. If Wrap is indicated, the next value reported after passing the 10 position in the increasing direction would be 0.
4	Linear Nonlinear	0 1	Indicates whether the raw data from the device has been processed in some way, and no longer represents a linear relationship between what is measured and the data that is reported. Acceleration curves and joystick dead zones are examples of this kind of data. Sensitivity settings would affect the Units item, but the data would still be linear.
5	Preferred State No Preferred	0 1	Indicates whether the control has a preferred state to which it will return when the user is not physically interacting with the control. Push buttons (as opposed to toggle buttons) and self-centering joysticks are examples.
6	Null State No Null Position	0 1	Indicates whether the control has a state in which it is not sending meaningful data. One possible use of the null state is for controls that require the user to physically interact with the control in order for it to report useful data. For example, some joysticks have a multidirectional switch (a hat switch). When a hat switch is not being pressed it is in a null state. When in a null state, the control will report a value outside of the specified Logical Minimum and Logical Maximum (the most negative value, such as -128 for an 8-bit value).
7	Non-volatile Volatile	0 1	Indicates whether the Feature or Output control's value should be changed by the host or not. Volatile output can change with or without host interaction. To avoid synchronization problems, volatile controls should be relative whenever possible. If volatile output is absolute, when issuing a Set Report (Output), request set the value of any control you don't want to change to a value outside of the specified Logical Minimum and Logical Maximum (the most negative value, such as -128 for an 8-bit value). Invalid output to a control is ignored by the device.
	Reserved	0	Data bit 7 is undefined for input items and is reserved for future use.

Bit	Part	Value	Description
8	Bit Field Buffered Bytes	0 1	Indicates that the control emits a fixed-size stream of bytes. The contents of the data field are determined by the application. The contents of the buffer are not interpreted as a single numeric quantity. Report data defined by a Buffered Bytes item must be aligned on an 8-bit boundary. The data from a bar code reader is an example.
9 - 31	Reserved	0	Reserved for future use.

Remarks

- If the **Main** item is a constant then none of the subsequent attributes apply. If the **Input** item is an array, only the Data/Constant, Variable/Array and Absolute/Relative attributes apply.
- The number of data fields in an item can be determined by examining the **Report Size** and **Report Count** values. For example an item with a **Report Size** of 8 bits and a **Report Count** of 3 has three 8-bit data fields.
- **Input** items define input reports accessible via the **Control** pipe with the **Get_Report (Input)** or **Set_Report (Input)** requests.
- **Input** type reports are also sent at the polling rate via the **Interrupt** pipe.
- The **Data | Constant, Variable | Array, Absolute | Relative, Nonlinear, Wrap,** and **Null State** data for an **Output** item are identical to those data for an **Input** item.
- **Output** items make **Output** reports accessible via the **Control** pipe with the **Get_Report (Output)** and **Set_Report (Output)** commands.
- While similar in function, **Output** and **Feature** items differ in the following ways:
 - **Feature** items define configuration options for the device and are usually set by a control panel application. Because they affect the behavior of a device (for example, button repeat rate, reset origin, and so forth), **Feature** items are not usually visible to software applications. Conversely, **Output** items represent device output to the user (for example, LEDs, audio, tactile feedback, and so forth). Software applications are likely to set device **Output** items.
 - **Feature** items may be attributes of other items. For example, an Origin Reset Feature may apply to one or more position **Input** items. Like **Output** items, **Feature** items make up Feature Reports accessible via the **Control** pipe with the **Get_Report (Feature)** and **Set_Report (Feature)** requests.

6.2.2.6 Collection, End Collection Items

Description

A **Collection** item identifies a relationship between two or more data (**Input**, **Output**, or **Feature**.) For example, a mouse could be described as a collection of two to four data (x, y, button 1, button 2). While the **Collection** item opens a collection of data, the **End Collection** item closes a collection.

Parts

Type of collection	Value	Description
Linked	0x00	A group of data describing data about a single object (like a point in space). A 3D device might have x, y and z position data in a single linked collection. Alternatively, a device could have two pointers with each x, y pair grouped in a separate linked collection. A joystick might report x and y axes, and the buttons on the stick inside a linked collection, while buttons on the base could be reported outside the collection. A voltmeter might group voltage, resistance, and amperage from a set of probes into a linked collection.
Application	0x01	A group of Main items that might be familiar to applications. It could also be used to identify item groups serving different purposes in a single device. Common examples are a keyboard or mouse. A keyboard with an integrated pointing device could be defined as two different application collections. Data reports are usually (but not necessarily) associated with application collections (one report ID per application).
Datalink	0x02	A group of data that are interrelated to each other. For example, a data size item may precede a byte buffer item and be associated with it. Or a 6D pointing device may report its physical orientation with a quaternion matrix representation, where each individual quantity has no direct physical correlate.
Reserved	0x03 - 0x7F	Reserved for future use.
	0x80 - 0xFF	Vendor-defined.

Remarks

- All **Main** items between the **Collection** item and the **End Collection** item are included in the collection. Collections may contain other nested collections.
- Collection items do not generate data. However, like all **Main** items, a **Usage** item tag may be associated with any collection (such as a mouse or throttle). **Collection** items may be nested, and they are always optional.

6.2.2.7 Global Items

Description **Global** items describe rather than define data from a control. A new **Main** item assumes the characteristics of the item state table. **Global** items can change the state table. As a result **Global** item tags apply to all subsequently defined items unless overridden by another **Global** item.

Parts	One-Byte Prefix (<i>nn</i> represents size value)	Description
Global item tag		
Usage Page	000001 <i>nn</i>	Specifies the current Usage Page. Since there are more than 256 usages, the Usage Page determines which set of usages are relevant. The Usage Tag points to a particular usage on a given Usage Page.
Logical Minimum	000101 <i>nn</i>	Extent value in logical units. This is the minimum value that a variable or array item will report. For example, a mouse reporting x position values from 0 to 128 would have a Logical Minimum of 0 and a Logical Maximum of 128.
Logical Maximum	001001 <i>nn</i>	Extent value in logical units. This is the maximum value that a variable or array item will report.
Physical Minimum	001101 <i>nn</i>	Minimum value for the physical extent of a variable item. This represents the Logical Minimum with units applied to it.
Physical Maximum	010001 <i>nn</i>	Maximum value for the physical extent of a variable item.
Unit Exponent	010101 <i>nn</i>	Value of the unit exponent in base 10. See the table later in this section for more information.
Unit	011001 <i>nn</i>	Unit values.
Report Size	011101 <i>nn</i>	Unsigned integer specifying the size of the report fields in bits. This allows the parser to build an item map for the report handler to use. For more information, see Section 8: Report Protocol.

Global item tag	One-Byte Prefix (<i>nn</i> represents size value)	Description
Report ID	100001 <i>nn</i>	<p>Specifies the Report ID. If a Report ID tag is used anywhere in Report descriptor, all data reports for the device are preceded by a single byte ID field. All items succeeding the first Report ID tag but preceding a second Report ID tag are included in a report prefixed by a 1-byte ID. All items succeeding the second but preceding a third Report ID tag are included in a second report prefixed by a second ID, and so on.</p> <p>This Report ID value indicates the prefix added to a particular report. For example, a Report descriptor could define a 3-byte report with a Report ID of 01. This device would generate a 4-byte data report in which the first byte is 01. The device may also generate other reports, each with a unique ID. This allows the host to distinguish different types of reports arriving over a single interrupt pipe. Report ID zero is reserved and should not be used.</p>
Report Count	100101 <i>nn</i>	Number of data fields for the item; determines how many fields are included in the report for this particular item (and consequently how many bits are added to the report).
Push	101001 <i>nn</i>	Places a copy of the item state table on the stack.
Pop	101101 <i>nn</i>	Replaces the item state table with the top structure from the stack.
Reserved	110001 <i>nn</i> to 111101 <i>nn</i>	Range reserved for future use.

See Also

For a list of **Usage Page** tags, see Appendix A: Usage Tags.

Remarks

- While **Logical Minimum** and **Logical Maximum** (extents) bound the values returned by a device, **Physical Minimum** and **Physical Maximum** give meaning to those bounds. For example, a thermometer might have logical extents of 0 and 999 but physical extents of 32 and 212 degrees.

The resolution can be calculated with the following formula:

$$\text{Resolution} = (\text{Logical Maximum} - \text{Logical Minimum}) / ((\text{Physical Maximum} - \text{Physical Minimum}) * (10^{\text{Unit Exponent}}))$$

For example, a 400-dpi mouse might have the items shown in the following table.

Item	Value
Logical Minimum	-127
Logical Maximum	127
Physical Minimum	-3175
Physical Maximum	3175
Unit Exponent	-4
Unit	Inches

Therefore, the formula for calculating resolution must be:

$$\text{Resolution} = (127 - (-127)) / ((3175 - (-3175)) * 10^{-4}) = 400 \text{ counts per inch}$$

- The **Unit** item qualifies values as described in the following table.

Nibble	System	0x0	0x1	0x2	0x3	0x4
	Exponent	0	1	2	3	4
0	System	None	SI Linear	SI Rotation	English Linear	English Rotation
1	Length	None	Centimeter	Radians	Inch	Degrees
2	Mass	None	Gram	Gram	Slug	Slug
3	Time	None	Seconds	Seconds	Seconds	Seconds
4	Temperature	None	Kelvin	Kelvin	Fahrenheit	Fahrenheit
5	Current	None	Ampere	Ampere	Ampere	Ampere
6	Luminous intensity	None	Candela	Candela	Candela	Candela
7	Reserved	None	None	None	None	None

Note For **System** part, codes 0x5 to 0xE are **Reserved**; code 0x7 is vendor-defined.

- Codes and exponents not shown in the preceding table:

Code	Exponent
0x5	5
0x6	6
0x7	7
0x8	-8
0x9	-7
0xA	-6
0xB	-5
0xC	-4
0xD	-3
0xE	-2
0xF	-1

- Most complex units can be derived from the basic units of length, mass, time, temperature, current and luminous intensity. For example energy (joules) can be represented as:

$$\text{joule} = [\text{mass}(\text{grams})][\text{length}(\text{centimeters})^2][\text{time}(\text{seconds})^{-2}]$$

The **Unit** exponent would be 7 because a joule is composed of kilograms (1 kg equals 103 grams) and meters. For example, consider the following.

Nibble	Part	Value
3	Time	-2
2	Mass	1
1	Length	2
0	System	1

- The parts of some common units are shown in the following table.

Unit	Nibbles							Code
	6(I)	5 (i)	4 (τ)	3 (t)	2 (m)	1 (1)	0 (sys)	
Distance	0	0	0	0	0	1	1	x0011
Mass	0	0	0	0	1	0	1	x0101
Time	0	0	0	1	0	0	1	x1001
Velocity	0	0	0	-1	0	1	1	xF011
Momentum	0	0	0	-1	1	1	1	xF111
Acceleration	0	0	0	-2	0	1	1	xE011
Force	0	0	0	-2	1	1	1	xE111
Energy	0	0	0	-2	1	2	1	xE121

Unit	Nibbles							Code
	6(I)	5 (i)	4 (τ)	3 (t)	2 (m)	1 (1)	0 (sys)	
Angular Acceleration	0	0	0	-2	0	1	2	xE012
Voltage	0	-1	0	-3	1	2	1	x00F0D121

- In the case of an array, **Report Count** determines the maximum number of controls that may be included in the report and consequently the number of keys or buttons that may simultaneously be pressed as well as the size of each element. For example, an array supporting up to three simultaneous key presses, where each field is 1 byte, would look like this:

```
...
Report Size (8),
Report Count(3),
...
```

In the case of a variable item, the **Report Count** specifies how many controls are included in the report. For example, eight buttons could look like this:

```
...
Report Size (1),
Report Count (8),
...
```

6.2.2.8 Local Items

Description

Local item tags define characteristics of controls. These items do not carry over to the next **Main** item. If a **Main** item defines more than one control, it may be preceded by several similar **Local** item tags. For example, an **Input** item may have several **Usage** tags associated with it, one for each control.

Parts

Tag	One-Byte Prefix (<i>nn</i> represents size value)	Description
Usage	000010 <i>nn</i>	Usage index for an item usage; represents a suggested usage for the item or collection. In the case where an item represents multiple controls, a Usage tag may suggest a usage for every variable or element in an array.
Usage Minimum	000110 <i>nn</i>	Defines the starting usage associated with an array or bitmap.
Usage Maximum	001010 <i>nn</i>	Defines the ending usage associated with an array or bitmap.
Designator Index	001110 <i>nn</i>	Determines the body part used for a control. Index points to a designator in the Physical descriptor.

Tag	One-Byte Prefix (<i>nn</i> represents size value)	Description
Designator Minimum	010010 <i>nn</i>	Defines the index of the starting designator associated with an array or bitmap.
Designator Maximum	010110	Defines the index of the ending designator associated with an array or bitmap.
String Index	011110 <i>nn</i>	String index for a String descriptor; allows a string to be associated with a particular item or control.
String Minimum	100010 <i>nn</i>	Specifies the first string index when assigning a group of sequential strings to controls in an array or bitmap.
String Maximum	100110 <i>nn</i>	Specifies the last string index when assigning a group of sequential strings to controls in an array or bitmap.
Set Delimiter	101010 <i>nn</i>	Defines the beginning or end of a set of local items (0 = open set, 1 = close set).
Reserved	101011 <i>nn</i> to 111110 <i>nn</i>	Reserved.

Remarks

- While **Local** items do not carry over to the next **Main** item, they may apply to more than one control within a single item. For example, if an **Input** item defining five controls is preceded by three **Usage** tags, the three usages would be assigned sequentially to the first three controls, and the third usage would also be assigned to the fourth and fifth controls. If an item has no controls (Report Count = 0), the **Local** item tags apply to the **Main** item (usually a collection item).
- To assign unique usages to every control in a single **Main** item, simply specify each **Usage** tag sequentially (or use **Usage Minimum** or **Usage Maximum**).

Note It is important that **Usage** be used properly. While very specific usages exist (landing gear, bicycle wheel, and so on) those usages are intended to identify devices that have very specific applications. A joystick with generic buttons should never assign an application-specific usage to any button. Instead, it should assign a generic usage such as “Button.” However, an exercise bicycle or the cockpit of a flight simulator may want to narrowly define the function of each of its data sources.

- It is also important to remember that **Usage** items convey information about the intended use for the data and may not correspond to what is actually being measured. For example, a joystick would have an **X** and **Y Usage** associated with its axis data (and not **Usages Rx** and **Ry**.)

See Also

For a list of Usage parts, see Appendix A: Usage Tags.

- Because button bitmaps and arrays can represent multiple buttons or switches with a single item, it may be useful to assign multiple usages to a **Main** item. **Usage Minimum** specifies the usage to be associated with the first unassociated control in the array or bitmap. **Usage Maximum** specifies the end of the range of usage values to be associated with item elements. The following example illustrates how this could be used for a 105-key keyboard.

Tag	Result
Report Count (1)	One field will be added to the report.
Report size (8)	The size of the newly added field is 1 byte (8 bits).
Logical Minimum (0)	Defines 0 as the lowest possible return value.
Logical Maximum (101)	Defines 101 as the highest possible return value and sets the range from 0 to 87.
Usage Page (0x07)	Selects keyboard usage page.
Usage Minimum (0x00)	Assigns first of 101-key usages.
Usage Maximum (0x65)	Assigns last of 101-key usages.
Input: (Data, Array, Absolute)	Creates and adds a 1-byte array to the input report.

- A control may have more than one usage, string or physical descriptor associated with it. One or more alternative sets of local items may be associated with a control by simply bracketing each set with **Set Delimiter** items. Alternative sets are always optional and may not be recognized by the operating system.

6.2.3 Physical Descriptors

A **Physical** descriptor is a data structure that provides information about the specific part or parts of the human body that are activating a control or controls. For example, a physical descriptor might indicate that the right hand thumb is used to activate button 5. An application can use this information to assign functionality to the controls of a device.

Note **Physical** descriptors are entirely optional. They add complexity and offer very little in return for most devices. However, some devices, particularly those with a large number of identical controls (for example, buttons) will find that **Physical** descriptors help different applications assign functionality to these controls in a more consistent manner. Skip the following section if you do not plan on supporting **Physical** descriptors.

Similar string descriptors are grouped into sets. **Physical Index** tags contained in the **Report** descriptor map items (or controls) to a specific **Physical** descriptor contained in a **Physical** descriptor set (hereafter referred to generically as a descriptor set).

Each descriptor set consists of a short header followed by one or more **Physical** descriptors. The header defines the **Bias** (whether the descriptor set is targeted at a right or left-handed user) and the **Preference** of the set. For a particular **Bias**, a vendor can define alternate **Physical** descriptors (for example, a right-handed user may be able to hold a device in more than one way, therefore remapping the fingers that touch the individual items).

Each **Physical** descriptor consists of the following three fields:

- **Designator**: identifies the actual body part that effects an item—for example, the hand.
- **Qualifier**: further defines the designator—for example, right or left hand.
- **Effort**: value quantifying the effort the user must employ to effect the item.

If multiple items identify the same **Designator/Qualifier** combination, the **Effort** value can be used to resolve the assignment of functions. An **Effort** value of 0 would be used to define the button a finger rests on when the hand is in the “at rest” position, that is, virtually no effort is required by the user to activate the button. **Effort** values increment as the finger has to stretch to reach a control.

The only time two or more controls will have identical **Designator/Qualifier/Effort** combinations is because they are physically connected together. A long skinny key cap with ‘+’ at one end and ‘-’ at the other is a good example of this. If it is implemented electrically as two discrete push-buttons, it is possible to have both pressed at the same time even though they are both under the same key cap. If the vendor decided that for this product, pressing

the '+' and '-' buttons simultaneously was valid then they would be described as two discrete push-buttons with identical **Physical** descriptors. However, if the key cap was labeled "Volume" and pressing both buttons at the same time had no meaning, then a vendor would probably choose to describe the buttons as a single item with three valid states: off, more volume (+), and less volume (-). In this case only one **Physical** descriptor would be needed.

Consider a joystick that has two buttons (A and B) on the left side of the base and a trigger button on the front of the stick that is logically OR'd with Button A. The joystick base is most often held in the left hand while the stick is manipulated with the right. So, the first **Designator** tag would designate Button A as:

Index Finger, Right, Effort 0

Similarly, button B would be designated as:

Thumb, Left, Effort 0

If the joystick was placed on a table top and the left hand was used to control both buttons on the base then another **Physical** descriptor could identify an alternate mapping for Button A of:

Middle Finger, Left, Effort 0

Button B would be designated as:

Index Finger, Left, Effort 0

Important Designator tags are optional and may be provided for all, some, or none of a device's items or elements.

Physical Descriptor 0 is a special descriptor that defines the number of **Physical** descriptors (the set header).

Part	Offset/Size (Bytes)	Description
<i>bNumber</i>	0/1	Numeric expression specifying the number of Physical descriptors. Do not include Physical Descriptor 0 itself in this number.
<i>bLength</i>	1/2	Numeric expression identifying the length of each Physical descriptor.

Upon receiving a **Get_Descriptor** request from the host, a **HID** class device will return the **Physical** descriptor specified in the request *wValue* low byte. A **Physical** descriptor consists of a header followed by one or more physical descriptors. A **Physical** descriptor is accessed by using the **Physical Index** that is defined in the **Report** descriptor.

The **HID** class device uses the following format for its **Physical** descriptor.

Part	Offset/Size (Bytes)	Description
<i>bPhysicalInfo</i>	0/1	Bits specifying physical information: 7..5 Bias 4..0 Preference 0 = Most preferred
<i>dPhysical</i>	1/2	Physical descriptor data, index 1.
<i>DPhysical</i>	3/2	Physical descriptor data, index 2.
<i>dPhysical</i>	(<i>n</i> *2)-1/2	Physical descriptor data, index <i>n</i> .

Remarks

- The **Bias** field indicates which hand the **Designator** set is characterizing. This may not apply to some devices.

Bias Value	Description
0	Not applicable
1	Right hand
2	Left hand
3	Both hands
4	Either hand
5	Reserved
6	Reserved
7	Reserved

Note A device that only fits in the right hand will not return **Physical** descriptors with a left-handed **Bias**.

- The **Preference** field indicates whether the **Physical** descriptor contains preferred or alternative designator information. A vendor will define the **Preference** value of 0 for the most preferred or most typical set of physical information. Higher **Preference** values indicate less preferred **Physical** descriptors.
- A **Physical** descriptor has the following parts.

Part	Offset/Size (Bytes)	Description
<i>bDesignator</i>	0/1	Designator value; indicates which part of the body affects the item
<i>bFlags</i>	1/1	Bits specifying flags: 7..5 Qualifier 4..0 Effort

Designator Value	Description
00	None

Designator Value	Description
01	Hand
02	Eyeball
03	Eyebrow
04	Eyelid
05	Ear
06	Nose
07	Mouth
08	Upper lip
09	Lower lip
0A	Jaw
0B	Neck
0C	Upper arm
0D	Elbow
0E	Forearm
0F	Wrist
10	Palm
11	Thumb
12	Index finger
13	Middle finger
14	Ring finger
15	Little finger
16	Head
17	Shoulder
18	Hip
19	Waist
1A	Thigh
1B	Knee
1C	Calf
1D	Ankle
1E	Foot
1F	Heel
20	Ball of foot
21	Big toe
22	Second toe
23	Third toe

Designator Value	Description
24	Fourth toe
25	Little toe
26	Brow
27	Cheek
28-FF	Reserved

- The **Qualifier** field indicates which hand (or half of the body) the designator is defining. This may not apply to for some devices.

Qualifier Value	Description
0	Not applicable
1	Right
2	Left
3	Both
4	Either
5	Center
6	Reserved
7	Reserved

- The **Effort** field indicates how easy it is for a user to access the control. A value of 0 identifies that the user can affect the control quickly and easily. As the value increases, it becomes more difficult or takes longer for the user to affect the control.

7. Requests

7.1 Standard Requests

The **HID** class uses the standard request **Get_Descriptor** as described in the USB Specification. When a **Get_Descriptor(Configuration)** request is issued, it returns the Configuration descriptor, all **Interface** descriptors, all **Endpoint** descriptors, and the **HID** descriptor for each interface. It shall not return the **String** descriptor, **HID Report** descriptor or any of the optional **HID** class descriptors. The **HID** descriptor shall be interleaved with the **Interface** and **Endpoint** descriptors. That is, the order shall be:

```
Configuration descriptor (other Interface, Endpoint, and Vendor Specific
descriptors if required)
  Interface descriptor (with Subclass and Protocol specifying bootable
  keyboard)
    Endpoint descriptor (HID Interrupt Endpoint)
      HID descriptor (associated with this Endpoint)
        (other Interface, Endpoint, and Vendor Specific descriptors if
        required).
```

Note **Get_Descriptor** can be used to retrieve standard, class, and vendor specific descriptors, depending on the setting of the descriptor **Type** field.

See Also

For details, see Chapter 9 of the USB Specification, “USB Device Class Framework.”

7.1.1 Get_Descriptor Request

Description

The **Get_Descriptor** request returns a descriptor for the device.

Parts

Part	From Device	From Endpoint
<i>bmRequestType</i>	10000000	10000010
<i>bRequest</i>	GET_DESCRIPTOR (0x06)	GET_DESCRIPTOR (0x06)
<i>wValue</i>	Descriptor Type and descriptor Index	Descriptor Type and descriptor Index
<i>wIndex</i>	0 (zero) or Language ID	Endpoint
<i>wLength</i>	Descriptor Length	Descriptor Length
<i>Data</i>	Descriptor	Descriptor

Remarks

- The *wValue* field specifies the descriptor **Type** in the high byte and the descriptor index in the low byte.
- The low byte is the descriptor **Index** used to specify the set for **Physical** descriptors and is reset to zero for other **HID** class descriptors.
- **Designator Set 0** returns a special descriptor identifying the number of sets and their sizes. If a standard descriptor is being requested then the *wIndex* field specifies the Language ID for string descriptors or is reset to zero for other descriptors. If a **HID** class descriptor is being requested then the *wIndex* field indicates source endpoint.
- A **Get_Descriptor** request with the **Physical Index** equal to 1 will request the first **Physical** descriptor. A device could possibly have alternate uses for its items. These can be enumerated by issuing subsequent **Get_Descriptor** requests while incrementing the **Physical Index**. The number of **Physical** descriptors is defined in a header is identified as:

```
Physical 0
```

A device will return the last **Physical** descriptor to requests greater than the last number defined in the **HID** descriptor.

7.1.2 Set_Descriptor Request

Description

The **Set_Descriptor** request lets the host change descriptors in the devices. Optional.

Parts

Part	To Device	To Endpoint
<i>bmRequestType</i>	00000000	00000010
<i>bRequest</i>	SET_DESCRIPTOR (0x07)	SET_DESCRIPTOR (0x07)
<i>wValue</i>	Descriptor Type (high) and Descriptor Index (low)	Descriptor Type and Descriptor Index
<i>wIndex</i>	0 (zero) or Language ID	Endpoint

Part	Offset/Size (Bytes)	Description
<i>bRequest</i>	1/1	A specific request.
<i>wValue</i>	2/2	Numeric expression specifying word-size field (varies according to request.)
<i>wIndex</i>	4/2	Index or offset specifying word-size field (varies according to request.)
<i>wLength</i>	6/2	Numeric expressions specifying number of bytes to transfer in the data phase.

Remarks The following table defines valid values of *bRequest*.

Value	Description
0x01	GET_REPORT ¹
0x02	GET_IDLE
0x03	GET_PROTOCOL ²
0x04-0x08	Reserved
0x09	SET_REPORT
0x0A	SET_IDLE
0x0B	SET_PROTOCOL ²

¹ This request is mandatory and must be supported by all devices.

² This request is required only for boot devices.

7.2.1 Get_Report Request

Description The **Get_Report** request allows the host to receive a report via the **Control** pipe.

Parts

Part	Description
<i>bmRequestType</i>	10100010
<i>bRequest</i>	GET_REPORT
<i>wValue</i>	Report Type and Report ID
<i>wIndex</i>	Endpoint
<i>wLength</i>	Report Length
<i>Data</i>	Report

7.2.2 Set_Report Request

Description The **Set_Report** request allows the host to send a report to the device, possibly setting the state of input, output, or feature controls.

Parts

Part	Description
<i>bmRequestType</i>	00100010
<i>bRequest</i>	SET_REPORT

Part	Description
<i>wValue</i>	Report Type and Report ID
<i>wIndex</i>	Endpoint
<i>wLength</i>	Report Length
<i>Data</i>	Report

Remarks

- A device might choose to ignore input **Set_Report** requests as meaningless. Alternatively these reports could be used to reset the origin of a control (that is, current position should report zero). The effect of sent reports will also depend on whether the recipient controls are absolute or relative.
- This request is useful at initialization time for absolute items and for determining the state of feature items. This request is not intended to be used for polling the device state on a regular basis.
- The **Interrupt** pipe should be used for recurring **Input** reports. The **Input** report reply has the same format as the reports from **Interrupt** pipe.
- Set **Report ID** to 0 (zero) if **Report IDs** are not used.

Value	Report Type
01	Input
02	Output
03	Feature
04-FF	Reserved

7.2.3 Get_Idle Request

Description

The **Get_Idle** request reads the current idle rate for a particular **Input** report (see: **Set_Idle** request).

Parts

Part	Description
<i>bmRequestType</i>	10100010
<i>bRequest</i>	GET_IDLE
<i>wValue</i>	0 (zero) and Report ID
<i>wIndex</i>	Endpoint
<i>wLength</i>	1 (one)
<i>Data</i>	Idle rate

7.2.4 Set_Idle Request

Description

The **Set_Idle** request silences a particular report on the **Interrupt** pipe until a new event occurs or the specified amount of time passes.

Parts	Part	Description
	<i>bmRequestType</i>	00100010
	<i>bRequest</i>	SET_IDLE
	<i>wValue</i>	Duration and Report ID
	<i>wIndex</i>	Endpoint
	<i>wLength</i>	0 (zero)
	<i>Data</i>	Not applicable

Remarks This request is used to limit the reporting frequency of an interrupt endpoint. Specifically, this request causes the endpoint to NAK any polls on an interrupt endpoint while its current report remains unchanged. In the absence of a change, polling will continue to be NAK'd for a given time-based duration. This request has the following parts.

Part	Description
Duration	<p>When the upper byte of <i>wValue</i> is 0 (zero), the duration is indefinite. The endpoint will inhibit reporting forever, only reporting when a change is detected in the report data.</p> <p>When the upper byte of <i>wValue</i> is non-zero, then a fixed duration is used. The duration will be linearly related to the value of the upper byte, with the LSB being weighted as 4 milliseconds. This provides a range of values from 0.004 to 1.020 seconds, with a 4 millisecond resolution. If the duration is less than the device polling rate, then reports are generated at the polling rate.</p> <p>If the given time duration elapses with no change in report data, then a single report will be generated by the endpoint and report inhibition will begin anew using the previous duration.</p>
Report ID	When the lower byte of <i>wValue</i> is non-zero, then the idle rate only applies to the Report ID specified by the value of the lower byte. For example a device with two input reports could specify an idle rate of 20 milliseconds for Report ID 1 and 500 milliseconds for Report ID 2.
Accuracy	This time duration shall have an accuracy of +/- (10% + 2 milliseconds)
Latency	<p>A new request will be executed as if it were issued immediately after the last report, if the new request is received at least 4 milliseconds before the end of the currently executing period. If the new request is received within 4 milliseconds of the end of the current period, then the new request will have no effect until after the report.</p> <p>If the current period has gone past the newly proscribed time duration, then a report will be generated immediately.</p>

If the interrupt endpoint is servicing multiple reports then the **Set_Idle** request affects only the rate duplicate reports are generated for the specified **Report ID**. For example, a device with two input reports could specify an idle rate of 20 milliseconds for report ID 1 and 500 milliseconds for report ID 2.

The recommended default idle rate (rate when the device is initialized) is 500 milliseconds for keyboards (delay before first repeat rate) and infinity for joysticks and mice.

7.2.5 Get_Protocol Request

Description The **Get_Protocol** request reads which protocol is currently active (either the boot protocol or the report protocol.)

Parts	Part	Description
	<i>bmRequestType</i>	10100010
	<i>bRequest</i>	GET_PROTOCOL
	<i>wValue</i>	0 (zero)
	<i>wIndex</i>	Endpoint
	<i>wLength</i>	1 (one)
	<i>Data</i>	0 = Boot 1 = Item

Remarks This request is supported by devices in the **Boot** subclass. The *wValue* field dictates which protocol should be used.

7.2.6 Set_Protocol Request

Description The **Set_Protocol** switches between the boot protocol and the report protocol (or vice versa).

Parts	Part	Description
	<i>bmRequestType</i>	00100010
	<i>bRequest</i>	SET_PROTOCOL
	<i>wValue</i>	0 = Boot 1 = Item
	<i>wIndex</i>	Endpoint
	<i>wLength</i>	0 (zero)
	<i>Data</i>	Not Applicable

Remarks This request is supported by devices in the boot subclass. The *wValue* field dictates which protocol should be used.

When initialized, all devices default to report protocol. However the host should not make any assumptions about the device's state and should set the desired protocol whenever initializing a device.

8. Report Protocol

8.1 Report Types

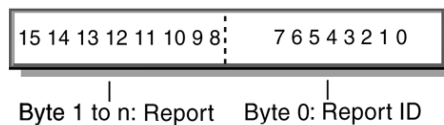
Reports contain data from one or more items. Data transfers are sent from the device to the host through the **Interrupt** pipe in the form of reports. Reports may also be requested (polled) and sent through the **Control** pipe. A report contains the state of all the items (**Input**, **Output** or **Feature**) belonging to a particular **Report ID**. The software application is responsible for extracting the individual items from the report based on the **Report** descriptor.

All of the items' values are packed on bit boundaries in the report (no byte or nibble alignment). However, items reporting Null or constant values must be used to byte-align values, or the **Report Size** may be made larger than needed for some fields simply to extend them to a byte boundary.

The bit length of an item's data is obtained through the **Report** descriptor (**Report Size * Report Count**). **Item** data is ordered just as items are ordered in the **Report** descriptor. If a **Report ID** tag was used in the **Report** descriptor, all reports include a single byte ID prefix. If the **Report ID** tag was not used, all values are returned in a single report and a prefix ID is not included in that report.

8.2 Report Format for Standard Items

The report format is composed of an 8-bit report identifier followed by the data belonging to this report.



Report ID

The **Report ID** field is 8 bits in length. If no **Report ID** tags are used in the **Report** descriptor, there is only one report and the **Report ID** field is omitted.

Report Data

The data fields are variable-length fields that report the state of an item.

8.3 Report Format for Array Items

Each button in an array reports an assigned number called an array index. This can be translated into a keycode by looking up the array elements **Usage Page** and **Usage**. When any button transitions between open and closed, the entire list of indices for buttons currently closed in the array is transmitted to the host.

Since only one array element can be reported in each array field, modifier keys should be reported as bitmap data (a group of 1-bit variable fields). For example, keys such as CTRL, SHIFT, ALT, and GUI keys make up the 8 bit modifier byte in a standard keyboard report. Although these usage codes are defined in the Usage Table as E0–E7, the usage is not sent as array data. The modifier byte is defined as follows.

Bit	Key
0	LEFT CTRL
1	LEFT SHIFT
2	LEFT ALT
3	LEFT GUI
4	RIGHT CTRL
5	RIGHT SHIFT
6	RIGHT ALT
7	RIGHT GUI

The following example shows the reports generated by a user typing ALT+CTRL+DEL, using a bitmap for the modifiers and a single array for all other keys.

Transition	Modifier Byte	Array Byte
LEFT ALT down	00000100	00
RIGHT CTRL down	00010100	00
DEL down	00010100	4C
DEL up	00010100	00
RIGHT CTRL up	00000100	00
LEFT ALT up	00000000	00

See Also

For a list of standard keyboard key codes, see Appendix A: Usage Tags.

If there are multiple reports for this device, all reports would be preceded by the **Report ID**.



If a set of keys or buttons cannot be mutually exclusive, they must be represented either as a bitmap or as multiple arrays. For example, function keys on a 101-key keyboard are sometimes used as modifier keys—for example, F1 A. In this case, at least two array fields should be reported in an array item (**Report Count** = 2).

8.4 Report Constraints

The following constraints apply to reports and to the report handler:

- An item field cannot span more than 4 bytes in a report. For example, a 32-bit item must start on a byte boundary to satisfy this condition.
- More than one report can be present in one USB transfer. For example, an 8-byte USB transfer could contain two **Input** reports.
- A report might span one or more USB transactions. For example, an application that has 10-byte reports will span at least two USB transactions in a low-speed device.
- A report is always byte-aligned. If required, reports are padded with bits (0) until the next byte boundary is reached.

8.5 Report Example

The following **Report** descriptor defines an item with an **Input** report.

```
Usage Page (Generic Desktop),
  Usage (Mouse),
Collection (Application),
  Usage (Pointer),
  Collection (Linked),
    Report ID (0A), ;Make changes to report 0A
    Usage (X), Usage (Y),
    Logical Minimum (-127), ;Report data values range from -127
    Logical Maximum (127), ;to 127
    Report Size (8), Report Count (2),
    Input (Data, Variable, Relative), ;Add 2 bytes of position data (X & Y) to report 0A
    Logical Minimum (0), ;Report data values range from -127
    Logical Maximum (1), ;to 127
    Report Count (1), Report Size (3),
    Usage Page (Page# for Buttons),
    Usage Minimum (1),
```

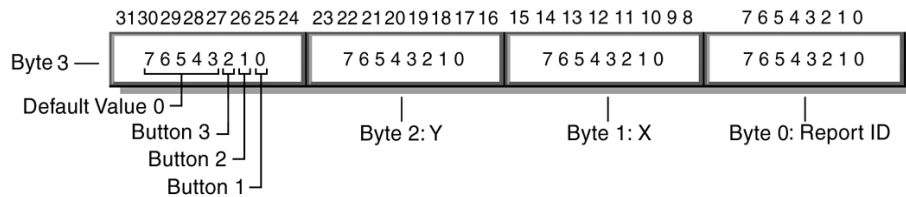


```

Usage Maximum (3),
Input (Data, Variable, Absolute), ;Add 2 bits (Button 1, 2 & 3) to report 0A
Report Size (5),
Input (Constant), ;Add 5 bits padding to byte align the report 0A
End Collection
End Collection

```

The **Input** report structure for the above device would look as follows.



The following table uses a keyboard with an integrated pointing device to demonstrate how to use two reports for a device with just one interface.

Item	Usages	Report ID
Collection (Application)	Keyboard	
Input (Variable, Absolute)	Modifier keys	00
Output (Variable, Absolute)	LEDs	00
Input (Array, Absolute)	Main keys	00
End Collection		
Collection (Application)	Mouse	
Collection (Linked)	Pointer	
Input (Variable, Relative)	X, Y	01
Input (Variable, Absolute)	Button	01
End Collection		
End Collection		

Note Only **Input**, **Output**, and **Feature** items (not **Collection** items) present data in a report. This example demonstrates multiple reports, however this interface would not be acceptable for a boot device (use separate interfaces for keyboards and mouse devices).

Appendix A: Usage Tags

See the supplemental **HID Usage** document for complete list of **Usage Tags**, including key codes for keyboards.

A.1 Usage Pages

The following is a list of currently defined **Usage Pages**.

Item ID	Item Name
00	Undefined
01	Generic desktop controls
02	Reserved
03	Reserved
04	Reserved
05	Reserved
06	Reserved
07	Keyboard/keypad keys
08	LEDs
09	Buttons
0A-FE	Reserved
FF	Vendor defined

A.2 Generic Desktop Page (0x01)

Item ID	Item Name
00	Undefined
01	Pointer
02	Mouse
03	Pen
04	Joystick
05	Gamepad
06	Keyboard
07	Keypad
08-2F	Reserved
30	X
31	Y
32	Z

Item ID	Item Name
33	Rx
34	Ry
35	Rz
36	Slider
37	Dial
38	Reserved
39	Hat switch
3A	Stylus
3B	Pen pressure
3C-FF	Reserved

A.3 Keyboard/Keypad Page (0x07)

This Section is the **Usage Page** for key codes to be used in implementing a USB keyboard. A bootable keyboard (84-, 101- or 104-key) should at a minimum support all associated usage codes as indicated in the “Bootable” column below.

Note A general note on **Usages** and languages: Due to the variation of keyboards from language to language, it is not feasible to specify exact key mappings for every language. Where this list is not specific for a key function in a language, the closest equivalent key position should be used, so that a keyboard may be modified for a different language by simply printing different keycaps. One example is the Y key on a North American keyboard. In Germany this is typically Z. Rather than changing the keyboard firmware to put the Z Usage into that place in the descriptor list, the vendor should use the Y Usage on both the North American and German keyboards. This continues to be the existing practice in the industry, in order to minimize the number of changes to the electronics to accommodate other languages.

Usage Index (Dec)	Usage Index (Hex)	Usage	Ref: Typical AT-101 Position	PC-AT	Mac	Unix	Bootable
0	00	Reserved (no event indicated) ⁹	N/A	√	√	√	84/101/104
1	01	Keyboard ErrorRollOver ⁹	N/A	√	√	√	84/101/104
2	02	Keyboard POSTFail ⁹	N/A	√	√	√	84/101/104
3	03	Keyboard ErrorUndefined ⁹	N/A	√	√	√	84/101/104
4	04	Keyboard a and A ⁴	31	√	√	√	84/101/104
5	05	Keyboard b and B	50	√	√	√	84/101/104
6	06	Keyboard c and C ⁴	48	√	√	√	84/101/104

Usage Index (Dec)	Usage Index (Hex)	Usage	Ref: Typical AT-101 Position	PC-AT	Mac	Unix	Bootable
7	07	Keyboard d and D	33	√	√	√	84/101/104
8	08	Keyboard e and E	19	√	√	√	84/101/104
9	09	Keyboard f and F	34	√	√	√	84/101/104
10	0A	Keyboard g and G	35	√	√	√	84/101/104
11	0B	Keyboard h and H	36	√	√	√	84/101/104
12	0C	Keyboard i and I	24	√	√	√	84/101/104
13	0D	Keyboard j and J	37	√	√	√	84/101/104
14	0E	Keyboard k and K	38	√	√	√	84/101/104
15	0F	Keyboard l and L	39	√	√	√	84/101/104
16	10	Keyboard m and M ⁴	52	√	√	√	84/101/104
17	11	Keyboard n and N	51	√	√	√	84/101/104
18	12	Keyboard o and O ⁴	25	√	√	√	84/101/104
19	13	Keyboard p and P ⁴	26	√	√	√	84/101/104
20	14	Keyboard q and Q ⁴	17	√	√	√	84/101/104
21	15	Keyboard r and R	20	√	√	√	84/101/104
22	16	Keyboard s and S ⁴	32	√	√	√	84/101/104
23	17	Keyboard t and T	21	√	√	√	84/101/104
24	18	Keyboard u and U	23	√	√	√	84/101/104
25	19	Keyboard v and V	49	√	√	√	84/101/104
26	1A	Keyboard w and W ⁴	18	√	√	√	84/101/104
27	1B	Keyboard x and X ⁴	47	√	√	√	84/101/104
28	1C	Keyboard y and Y ⁴	22	√	√	√	84/101/104
29	1D	Keyboard z and Z ⁴	46	√	√	√	84/101/104
30	1E	Keyboard 1 and ! ⁴	2	√	√	√	84/101/104
31	1F	Keyboard 2 and @ ⁴	3	√	√	√	84/101/104
32	20	Keyboard 3 and # ⁴	4	√	√	√	84/101/104
33	21	Keyboard 4 and \$ ⁴	5	√	√	√	84/101/104
34	22	Keyboard 5 and % ⁴	6	√	√	√	84/101/104
35	23	Keyboard 6 and ^ ⁴	7	√	√	√	84/101/104
36	24	Keyboard 7 and & ⁴	8	√	√	√	84/101/104
37	25	Keyboard 8 and * ⁴	9	√	√	√	84/101/104
38	26	Keyboard 9 and (⁴	10	√	√	√	84/101/104
39	27	Keyboard 0 and) ⁴	11	√	√	√	84/101/104
40	28	Keyboard Return (ENTER) ⁵	43	√	√	√	84/101/104

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Usage Index (Dec)	Usage Index (Hex)	Usage	Ref: Typical AT-101 Position	PC-AT	Mac	Unix	Bootable
41	29	Keyboard ESCAPE	110	√	√	√	84/101/104
42	2A	Keyboard DELETE (Backspace) ¹³	15	√	√	√	84/101/104
43	2B	Keyboard Tab	16	√	√	√	84/101/104
44	2C	Keyboard Spacebar	61	√	√	√	84/101/104
45	2D	Keyboard - and (underscore) ⁴	12	√	√	√	84/101/104
46	2E	Keyboard = and + ⁴	13	√	√	√	84/101/104
47	2F	Keyboard [and { ⁴	27	√	√	√	84/101/104
48	30	Keyboard] and } ⁴	28	√	√	√	84/101/104
49	31	Keyboard \ and	29	√	√	√	84/101/104
50	32	Keyboard Non-U.S. # and ~ ²	42	√	√	√	84/101/104
51	33	Keyboard ; and : ⁴	40	√	√	√	84/101/104
52	34	Keyboard ‘ and “ ⁴	41	√	√	√	84/101/104
53	35	Keyboard Grave Accent and Tilde ⁴	1	√	√	√	84/101/104
54	36	Keyboard, and < ⁴	53	√	√	√	84/101/104
55	37	Keyboard . and > ⁴	54	√	√	√	84/101/104
56	38	Keyboard / and ? ⁴	55	√	√	√	84/101/104
57	39	Keyboard CapsLock ¹¹	30	√	√	√	84/101/104
58	3A	Keyboard F1	112	√	√	√	84/101/104
59	3B	Keyboard F2	113	√	√	√	84/101/104
60	3C	Keyboard F3	114	√	√	√	84/101/104
61	3D	Keyboard F4	115	√	√	√	84/101/104
62	3E	Keyboard F5	116	√	√	√	84/101/104
63	3F	Keyboard F6	117	√	√	√	84/101/104
64	40	Keyboard F7	118	√	√	√	84/101/104
65	41	Keyboard F8	119	√	√	√	84/101/104
66	42	Keyboard F9	120	√	√	√	84/101/104
67	43	Keyboard F10	121	√	√	√	84/101/104
68	44	Keyboard F11	122	√	√	√	101/104
69	45	Keyboard F12	123	√	√	√	101/104
70	46	Keyboard PrintScreen ¹	124	√	√	√	101/104
71	47	Keyboard ScrollLock ¹¹	125	√	√	√	84/101/104
72	48	Keyboard Pause ¹	126	√	√	√	101/104

Usage Index (Dec)	Usage Index (Hex)	Usage	Ref: Typical AT-101 Position	PC-AT	Mac	Unix	Bootable
73	49	Keyboard Insert ¹	75	√	√	√	101/104
74	4A	Keyboard Home ¹	80	√	√	√	101/104
75	4B	Keyboard PageUp ¹	85	√	√	√	101/104
76	4C	Keyboard Delete Forward ^{1;14}	76	√	√	√	101/104
77	4D	Keyboard End ¹	81	√	√	√	101/104
78	4E	Keyboard PageDown ¹	86	√	√	√	101/104
79	4F	Keyboard RightArrow ¹	89	√	√	√	101/104
80	50	Keyboard LeftArrow ¹	79	√	√	√	101/104
81	51	Keyboard DownArrow ¹	84	√	√	√	101/104
82	52	Keyboard UpArrow ¹	83	√	√	√	101/104
83	53	Keypad NumLock and Clear ¹¹	90	√	√	√	101/104
84	54	Keypad /1	95	√	√	√	101/104
85	55	Keypad *	100	√	√	√	84/101/104
86	56	Keypad -	105	√	√	√	84/101/104
87	57	Keypad +	106	√	√	√	84/101/104
88	58	Keypad ENTER ⁵	108	√	√	√	101/104
89	59	Keypad 1 and End	93	√	√	√	84/101/104
90	5A	Keypad 2 and Down Arrow	98	√	√	√	84/101/104
91	5B	Keypad 3 and PageDn	103	√	√	√	84/101/104
92	5C	Keypad 4 and Left Arrow	92	√	√	√	84/101/104
93	5D	Keypad 5	97	√	√	√	84/101/104
94	5E	Keypad 6 and Right Arrow	102	√	√	√	84/101/104
95	5F	Keypad 7 and Home	91	√	√	√	84/101/104
96	60	Keypad 8 and Up Arrow	96	√	√	√	84/101/104
97	61	Keypad 9 and PageUp	101	√	√	√	84/101/104
98	62	Keypad 0 and Insert	99	√	√	√	84/101/104
99	63	Keypad . and Delete	104	√	√	√	84/101/104
100	64	Keyboard Non-U.S. \ and ^{3;6}	45	√	√	√	84/101/104
101	65	Keyboard Application ¹⁰	129	√		√	104
102	66	Keyboard Power ⁹			√	√	
103	67	Keypad =			√		
104	68	Keyboard F13			√		
105	69	Keyboard F14			√		
106	6A	Keyboard F15			√		

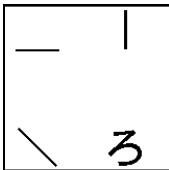
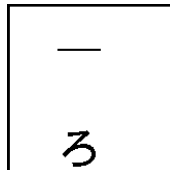

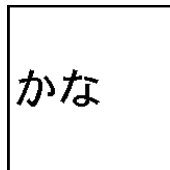
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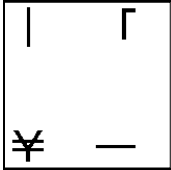
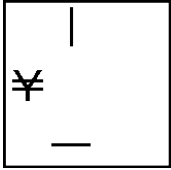




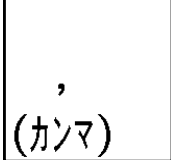
Usage Index (Dec)	Usage Index (Hex)	Usage	Ref: Typical AT-101 Position	PC-AT	Mac	Unix	Bootable
107	6B	Keyboard F16					
108	6C	Keyboard F17					
109	6D	Keyboard F18					
110	6E	Keyboard F19					
111	6F	Keyboard F20					
112	70	Keyboard F21					
113	71	Keyboard F22					
114	72	Keyboard F23					
115	73	Keyboard F24					
116	74	Keyboard Execute				√	
117	75	Keyboard Help				√	
118	76	Keyboard Menu				√	
119	77	Keyboard Select				√	
120	78	Keyboard Stop				√	
121	79	Keyboard Again				√	
122	7A	Keyboard Undo				√	
123	7B	Keyboard Cut				√	
124	7C	Keyboard Copy				√	
125	7D	Keyboard Paste				√	
126	7E	Keyboard Find				√	
127	7F	Keyboard Mute				√	
128	80	Keyboard Volume Up				√	
129	81	Keyboard Volume Down				√	
130	82	Keyboard Locking CapsLock ¹²				√	
131	83	Keyboard Locking NumLock ¹²				√	
132	84	Keyboard Locking ScrollLock ¹²				√	
133	85	Keypad Comma					
134	86	Keypad Equal Sign					
135	87	Keyboard Kanji ¹⁵					
136	88	Keyboard Kanji ²¹⁶					
137	89	Keyboard Kanji ³¹⁷					
138	8A	Keyboard Kanji ⁴¹⁸					
139	8B	Keyboard Kanji ⁵¹⁹					

Usage Index (Dec)	Usage Index (Hex)	Usage	Ref: Typical AT-101 Position	PC-AT	Mac	Unix	Bootable
140	8C	Keyboard Kanji6 ²⁰					
141	8D	Keyboard Kanji7 ²¹					
142	8E	Keyboard Kanji8 ²²					
143	8F	Keyboard Kanji9 ²²					
144	90	Keyboard LANG1 ⁸					
145	91	Keyboard LANG2 ⁸					
146	92	Keyboard LANG3 ⁸					
147	93	Keyboard LANG4 ⁸					
148	94	Keyboard LANG5 ⁸					
149	95	Keyboard LANG6 ⁸					
150	96	Keyboard LANG7 ⁸					
151	97	Keyboard LANG8 ⁸					
152	98	Keyboard LANG9 ⁸					
153	99	Keyboard Alternate Erase ⁷					
154	9A	Keyboard SysReq/Attention ¹					
155	9B	Keyboard Cancel					
156	9C	Keyboard Clear					
157	9D	Keyboard Prior					
158	9E	Keyboard Return					
159	9F	Keyboard Separator					
160	A0	Keyboard Out					
161	A1	Keyboard Oper					
162	A2	Keyboard Clear/Again					
163	A3	Keyboard CrSel/Props					
164	A4	Keyboard ExSel					
165-223	A5-DF	Reserved					
224	E0	Keyboard LeftControl	58	√	√	√	84/101/104
225	E1	Keyboard LeftShift	44	√	√	√	84/101/104
226	E2	Keyboard LeftAlt	60	√	√	√	84/101/104
227	E3	Keyboard Left GUI ^{10;23}	127	√	√	√	104
228	E4	Keyboard RightControl	64	√	√	√	101/104
229	E5	Keyboard RightShift	57	√	√	√	84/101/104
230	E6	Keyboard RightAlt	62	√	√	√	101/104
231	E7	Keyboard Right GUI ^{10;24}	128	√	√	√	104

Usage Index (Dec)	Usage Index (Hex)	Usage	Ref: Typical AT-101 Position	PC-AT	Mac	Unix	Bootable	
232-255	E8-FF	Reserved						
1		Usage of keys is not modified by the state of the Control, Alt, Shift or NumLock keys. That is, a key does not send extra codes to compensate for the state of any Control, Alt, Shift or NumLock keys.						
2		Typical language mappings: US: \ Belg: µ`£ FrCa: <> Dan: '* Dutch: <> Fren:*µ Ger: #' Ital: ù\$ LatAm: `] Nor:,* Span: }Ç Swed: ,* Swiss: \$£ UK: #-.						
3		Typical language mappings: Belg:<> FrCa:«°» Dan:<> Dutch:][Fren:<> Ger:<> Ital:<> LatAm:<> Nor:<> Span:<> Swed:<> Swiss:<> UK:\ Brazil: \.						
4		Typically remapped for other languages in the host system.						
5		Keyboard Enter and Keypad Enter generate different Usage codes.						
6		Typically near the Left-Shift key in AT-102 implementations.						
7		Example, Erase-Eaze™ key.						
8		Reserved for language-specific functions, such as Front End Processors and Input Method Editors.						
9		Reserved for typical keyboard status or keyboard errors. Sent as a member of the keyboard array. Not a physical key.						
10		Windows key for Windows 95, and “Compose.”						
11		Implemented as a non-locking key; sent as member of an array.						
12		Implemented as a locking key; sent as a toggle button. Available for legacy support; however, most systems should use the non-locking version of this key.						
13		Backs up the cursor one position, deleting a character as it goes.						
14		Deletes one character without changing position.						
21		Toggle Double-Byte/Single-Byte mode.						
22		Undefined, available for other Front End Language Processors.						
23		Windowing environment key, examples are Microsoft Left Win key, Mac Left Apple key, Sun Left Meta key						
24		Windowing environment key, examples are Microsoft® RIGHT WIN key, Macintosh® RIGHT APPLE key, Sun® RIGHT META key.						

Footnotes 15–20

Note	AT-104	DOS/V-109 (suggested)	PC98 (suggested)
15	No function		
16	No function		

17	No function		
18	No function		
19	No function		
20	No function	No function	

A.4 LED Page (0x08)

Item ID	Item Name	Item ID	Item Name
00	Undefined	1E	Speaker
01	Num Lock	1F	Head Set
02	Caps Lock	20	Hold
03	Scroll Lock	21	Microphone
04	Compose	22	Coverage
05	Kana	23	Night Mode
06	Power	24	Send Calls
07	Shift	25	Call Pickup
08	Do Not Disturb	26	Conference
09	Mute	27	Stand-by
0A	Tone Enable	28	Camera On
0B	High Cut Filter	29	Camera Off
0C	Low Cut Filter	2A	On-Line
0D	Equalizer Enable	2B	Off-Line
0E	Sound Field On	2C	Busy
0F	Surround field On	2D	Ready
10	Repeat	2E	Paper-Out
11	Stereo	2F	Paper-Jam
12	Sampling Rate Detect	30	Remote
13	Spinning	31	Forward
14	CAV	32	Reverse
15	CLV	33	Stop
16	Recording Format Detect	34	Rewind
17	Off-Hook	35	Fast Forward
18	Ring	36	Play
19	Message Waiting	37	Pause
1A	Data Mode	38	Record
1B	Battery Operation	39	Error
1C	Battery OK	3A-FF	Reserved
1D	Battery Low		

A.5 Button Page (0x09)

Item ID	Item Name
00	No button pressed
01	Button 1 (primary/trigger)
02	Button 2 (secondary)
03	Button 3 (tertiary)
04	Button 4
...	...
FF	Button 255

Appendix B: Boot Interface Descriptors

The **HID** Subclass 1 defines two descriptors for boot devices. Devices may append additional data to these boot reports, but the first 8 bytes of keyboard reports and the first 3 bytes of mouse reports must conform to the format defined by the **Boot Report** descriptor in order for the data to be correctly interpreted by the BIOS. The report may not exceed 8 bytes in length. The BIOS will ignore any extensions to reports. These descriptors describe reports that the BIOS expects to see. However, since the BIOS does not actually read the **Report** descriptors, these descriptors do not have to be hard-coded into the device. Instead, descriptors that describe the device reports in a USB-aware operating system should be included (these may or may not be the same). When the **HID** class driver is loaded, it will issue a Change Protocol, changing from the boot protocol to the report protocol after reading the boot interface's **Report** descriptor.

B.1 Protocol 1 (Keyboard)

The following represents a **Report** descriptor for a boot interface for a keyboard.

```
Usage Page (Generic Desktop), Usage (Keyboard),
Collection (Application),
    Usage Page (Key Codes)                                ;Usage Minimum (224)
    Usage Maximum (231), Logical Minimum (0),
    Logical Maximum (1), Report Size (1), Report Count (8),
    Input (Data, Variable, Absolute),                    ;Modifier byte
    Report Count (1), Report Size (8),
    Input (Constant),                                    ;Reserved byte
    Report Count (5), Report Size (1), Usage Page (LEDs),
    Usage Minimum (1), Usage Maximum (5),
    Output (Data, Variable, Absolute),                    ;LED report
    Report Count (1), Report Size (3),
    Output (Constant),                                    ;LED report padding
    Report Count (6), Report Size (8), Logical Minimum (0),
    Logical Maximum(255), Usage Page (Key Codes),
    Usage Minimum (0), Usage Maximum (255),
    Input (Data, Array),
End Collection
```

Byte	Description
0	Modifier keys
1	Reserved
2	Keycode 1
3	Keycode 2

Byte	Description
4	Keycode 3
5	Keycode 4
6	Keycode 5
7	Keycode 6

Note Byte 1 of this report is a constant. This byte is reserved for OEM use. The BIOS should ignore this field if it is not used. Returning zeros in unused fields is recommended.

The following table represents the modifier byte.

Bit	Description
0	NUMLOCK
1	CAPSLOCK
2	SCROLL LOCK
3	COMPOSE
4	KANA
5 to 7	CONSTANT

Note The LEDs are absolute output items. This means that the state of each LED must be included in output reports (0 = off, 1 = on). Relative items would permit reports that affect only selected controls (0 = no change, 1 = change).

B.2 Protocol 2 (Mouse)

The following illustration represents a **Report** descriptor for a boot interface for a mouse.

```
Usage Page (Generic Desktop), Usage (Mouse),
Collection (Application),
    Usage (Pointer),
    Collection (Linked),
        Usage Page (Buttons), Usage Minimum (1),
        Usage Maximum (3), Logical Minimum (0),
        Logical Maximum (1), Report Count (3), Report Size (1),
        Input (Data, Variable, Absolute),
        Report Count (1), Report Size (5),
        Input (Constant),
        Usage Page (Generic Desktop), Usage (X), Usage (Y),
        Logical Minimum (-127), Logical Maximum (127),
        Report Size (8), Report Count (2),
        Input (Data, Variable, Relative),
    End Collection,
```

End Collection

Byte	Bits	Description
0	0	Button 1
	1	Button 2
	2	Button 3
	4 to 7	Device-specific
1	0 to 7	X displacement
2	0 to 7	Y displacement
3 to n	0 to 7	Device specific

Appendix C: Keyboard Implementation

The following are design requirements for USB keyboards:

- Non-modifier keys must be reported in Input (Array, Absolute) items. Reports must contain a list of keys currently pressed and not make/break codes (relative data).
- The keyboard must send data reports at the Idle rate or when receiving a **Get_Report** request, even when there are no new key events.
- The keyboard must support the **Idle** request.
- The keyboard must report a phantom state in all array fields when the number of keys pressed exceeds the Report Count. The limit is six non-modifier keys when using the keyboard descriptor in Appendix B. Additionally, a keyboard may report the phantom condition when an invalid or unrecognizable combination of keys is pressed.
- The order of keycodes in array fields has no significance. Order determination is done by the host software comparing the contents of the previous report to the current report. If two or more keys are reported in one report, their order is indeterminate. Keyboards may buffer events that would have otherwise resulted in multiple event in a single report.
- “Repeat Rate” and “Delay Before First Repeat” are implemented by the host and not in the keyboard (this means the BIOS in legacy mode). The host may use the device report rate and the number of reports to determine how long a key is being held down. Alternatively, the host may use its own clock or the idle request for the timing of these features.
- Synchronization between LED states and CAPS LOCK, NUM LOCK, SCROLL LOCK, COMPOSE, and KANA events is maintained by the host and NOT the keyboard. If using the keyboard descriptor in Appendix B, LED states are set by sending a 5-bit absolute report to the keyboard via a **Set_Report(Output)** request.
- For boot keyboards, the reported index for a given key must be the same value as the key usage for that key. This is required because the BIOS will not read the **Report** descriptor. It is recommended (but not required) that non-legacy protocols also try to maintain a one-to-one correspondence between indices and **Usage Tags** where possible.

- Boot keyboards must support the boot protocol and the **Set_Protocol** request. Boot keyboards may support an alternative protocol (specified in the **Report** descriptor) for use in USB-aware operating environments.

Key Event	Modifier Byte	Array	Array	Array	Comment
None	0000000B	00H	00H	00H	
RALT down	01000000	00	00	00	
None	01000000	00	00	00	Report current key state even when no new key events.
A down	01000000	04	00	00	
X down	01000000	04	1B	00	
B down	01000000	04	05	1B	Report order is arbitrary and does not reflect order of events.
Q down	01000000	01	01	01	Phantom state. Four Array keys pressed. Modifiers still reported.
A up	01000000	05	14	1B	
B and Q up	01000000	1B	00	00	Multiple events in one report. Event order is indeterminate.
None	01000000	1B	00	00	
RALT up	00000000	1B	00	00	
X up	00000000	00	00	00	

Note This example uses a 4-byte report so that the phantom condition can be more easily demonstrated. Most keyboards should have 8 or more bytes in their reports.

Appendix D: Example Report Descriptors

The following are example descriptors for common devices. These examples are provided only to assist in understanding this specification and are not intended as definitive solutions.

D.1 Example Joystick Descriptor

```
Usage Page (Page#), Usage (Joystick), Report Count (0),
Collection (Application),
  Usage Page (Page#), Usage (Pointer),
  Collection (Linked),
    Logical Minimum (-127), Logical Maximum (127), Report Size (8),
    Report Count (2), Push, Usage (X), Usage (Y),
    Input (Data, Variable, Absolute),
    Usage (Hat switch), Logical Minimum (0), Logical Maximum (3), Physical Minimum 0),
    Physical Maximum (270), Unit (Degrees), Report Count (1), Report Size (4),
    Input (Data, Variable, Absolute, Null State),
    Logical Minimum (0), Logical Maximum (1), Report Count (2), Report Size (1),
    Usage Page (Page# for Buttons), Usage (Button), Unit (None),
    Input (Data, Variable, Absolute)
  End Collection,
  Usage (Button)
  Input (Data, Variable, Absolute),
  Pop, Usage (Throttle), Report Count (1),
  Input (Data, Variable, Absolute),
End Collection
```

Byte	Bits	Description
0	0 to 7	X position
1	0 to 7	Y position
2	0 to 3	Hat switch
	4	Button 1
	5	Button 2
	6	Button 3
	7	Button 4
3	0 to 7	Throttle

Note While the hat switch item only requires 3 bits, it is allocated 4 bits in the report. This conveniently byte-aligns the remainder of the report.

Appendix E: Example USB Descriptors for HID Class Devices

This appendix contains a sample set of descriptors for an imaginary product.

Caution This sample is intended for use as an instructional tool. Do NOT copy this information verbatim—even if building a similar device. It is important to understand the function of every field in every descriptor and why each value was chosen.

The sample device is a low-speed 105-key keyboard with an integrated pointing device. This device could be built using just one interface. However, two are used in this example so the device can support the boot protocol. As a result there are two **Interface**, **Endpoint**, **HID** and **Report** descriptors for this device.

E.1 Device Descriptor

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	0/1	Numeric expression specifying the size of this descriptor.	0x12
<i>bDescriptorType</i>	1/1	Device descriptor type (assigned by USB).	0x01
<i>bcdUSB</i>	2/2	USB HID Specification Release 1.0.	0x100
<i>bDeviceClass</i>	4/1	Class code (assigned by USB). Note that the HID class is defined in the Interface descriptor.	0x00
<i>bDeviceSubClass</i>	5/1	Subclass code (assigned by USB). These codes are qualified by the value of the <i>bDeviceClass</i> field.	0x00
<i>bDeviceProtocol</i>	6/1	Protocol code. These codes are qualified by the value of the <i>bDeviceSubclass</i> field.	0x00
<i>bMaxPacketSize0</i>	7/1	Maximum packet size for endpoint zero (only 8, 16, 32, or 64 are valid).	0x08
<i>idVendor</i>	8/2	Vendor ID (assigned by USB). For this example we'll use xFFFF.	0xFFFF
<i>idProduct</i>	10/2	Product ID (assigned by manufacturer).	0x0001
<i>bcdDevice</i>	12/2	Device release number (assigned by manufacturer).	0x0100
<i>iManufacturer</i>	14/1	Index of String descriptor describing manufacturer.	0x04
<i>iProduct</i>	15/1	Index of string descriptor describing product.	0x0E

Part	Offset/Size (Bytes)	Description	Sample Value
<i>iSerialNumber</i>	16/1	Index of String descriptor describing the device's serial number.	0x30
<i>bNumConfigurations</i>	17/1	Number of possible configurations.	0x01

E.2 Configuration Descriptor

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	0/1	Size of this descriptor in bytes.	0x09
<i>bDescriptorType</i>	1/1	Configuration (assigned by USB).	0x02
<i>wTotalLength</i>	2/2	Total length of data returned for this configuration. Includes the combined length of all returned descriptors (configuration, interface, endpoint, and HID) returned for this configuration. This value includes the HID descriptor but none of the other HID class descriptors (report or designator).	0x00AC
<i>bNumInterfaces</i>	4/1	Number of interfaces supported by this configuration.	0x02
<i>bConfigurationValue</i>	5/1	Value to use as an argument to Set Configuration to select this configuration.	0x01
<i>iConfiguration</i>	6/1	Index of string descriptor describing this configuration. In this case there is none.	0x00
<i>bmAttributes</i>	7/1	Configuration characteristics 7 Bus Powered 6 Self Powered 5 Remote Wakeup 4..0 Reserved (reset to 0)	10100000B
<i>MaxPower</i>	8/1	Maximum power consumption of USB device from bus in this specific configuration when the device is fully operational. Expressed in 2 mA units—for example, 50 = 100 mA. The number chosen for this example is arbitrary.	0x32

E.3 Interface Descriptor (Keyboard)

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	0/1	Size of this descriptor in bytes.	0x09
<i>bDescriptorType</i>	1/1	Interface descriptor type (assigned by USB).	0x04
<i>bInterfaceNumber</i>	2/1	Number of interface. Zero-based value identifying the index in the array of concurrent interfaces supported by this configuration.	0x00

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bAlternateSetting</i>	3/1	Value used to select alternate setting for the interface identified in the prior field.	0x00
<i>bNumEndpoints</i>	4/1	Number of endpoints used by this interface (excluding endpoint zero). If this value is zero, this interface only uses endpoint zero.	0x01
<i>bInterfaceClass</i>	5/1	Class code (HID code assigned by USB).	0x03
<i>bInterfaceSubClass</i>	6/1	Subclass code. 0 No subclass 1 Boot Interface subclass	0x01
<i>bInterfaceProtocol</i>	7/1	Protocol code. 0 None 1 Keyboard 2 Mouse	0x01
<i>iInterface</i>	8/1	Index of string descriptor describing this interface.	0x00

E.4 Endpoint Descriptor (Keyboard)

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	0/1	Size of this descriptor in bytes.	0x07
<i>bDescriptorType</i>	1/1	Endpoint descriptor type (assigned by USB).	0x05
<i>bEndpointAddress</i>	2/1	The address of the endpoint on the USB device described by this descriptor. The address is encoded as follows: Bit 0..3 The endpoint number Bit 4..6 Reserved, reset to zero Bit 7 Direction, ignored for Control endpoints: 0 OUT endpoint 1 IN endpoint	10000001B
<i>bmAttributes</i>	3/1	This field describes the endpoint's attributes when it is configured using the <i>bConfigurationValue</i> . Bit 0..1 Transfer type: 00 Control 01 Isochronous 10 Bulk 11 Interrupt All other bits are reserved.	00000011B

Part	Offset/Size (Bytes)	Description	Sample Value
<i>wMaxPacketSize</i>	4/1	Maximum packet size this endpoint is capable of sending or receiving when this configuration is selected. For interrupt endpoints, this value is used to reserve the bus time in the schedule, required for the per frame data payloads. Smaller data payloads may be sent, but will terminate the transfer and thus require intervention to restart.	0x08
<i>bInterval</i>	6/1	Interval for polling endpoint for data transfers. Expressed in milliseconds.	0x0A

E.5 HID Descriptor (Keyboard)

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	0/1	Size of this descriptor in bytes.	0x09
<i>bDescriptorType</i>	1/1	HID descriptor type (assigned by USB).	0x01
<i>bcdHID</i>	2/2	HID Class Specification release number in binary-coded decimal—for example, 2.10 is 0x210).	0x100
<i>bCountryCode</i>	4/1	Hardware target country.	0x00
<i>bNumDescriptors</i>	5/1	Number of HID class descriptors to follow.	0x01
<i>bDescriptorType</i>	6/1	Report descriptor type.	0x02
<i>wItemLength</i>	7/2	Total length of Report descriptor.	0x3F

E.6 Report Descriptor (Keyboard)

Item	Value (Hex)
Usage Page (Generic Desktop),	05 01
Usage (Keyboard),	09 06
Collection (Application),	A1 01
Usage Page (Key Codes);	05 07
Usage Minimum (224),	19 E0
Usage Maximum (231),	29 E7
Logical Minimum (0),	15 00
Logical Maximum (1),	25 01
Report Size (1),	75 01
Report Count (8),	95 08
Input (Data, Variable, Absolute),	:Modifier byte 81 02
Report Count (1),	95 01
Report Size (8),	75 08
Input (Constant),	:Reserved byte 81 01
Report Count (5),	95 05
Report Size (1),	75 01
Usage Page (Page# for LEDs),	05 08
Usage Minimum (1),	19 01
Usage Maximum (5),	29 05
Output (Data, Variable, Absolute),	:LED report 91 02
Report Count (1),	95 01
Report Size (3),	75 03
Output (Constant),	:LED report padding 91 01
Report Count (6),	95 06
Report Size (8),	75 08
Logical Minimum (0),	15 00
Logical Maximum(101),	25 65
Usage Page (Key Codes),	05 07
Usage Minimum (0),	19 00
Usage Maximum (101),	29 65
Input (Data, Array),	:Key arrays (6 bytes) 81 00
End Collection	C0

E.7 Interface Descriptor (Mouse)

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	0/1	Size of this descriptor in bytes.	0x09
<i>bDescriptorType</i>	1/1	Interface descriptor type (assigned by USB).	0x04
<i>bInterfaceNumber</i>	2/1	Number of interface.	0x01
<i>bAlternateSetting</i>	3/1	Value used to select alternate setting.	0x00
<i>bNumEndpoints</i>	4/1	Number of endpoints.	0x01
<i>bInterfaceClass</i>	5/1	Class code (HID code assigned by USB).	0x03
<i>bInterfaceSubClass</i>	6/1	1 = Boot Interface subclass.	0x01
<i>bInterfaceProtocol</i>	7/1	2 = Mouse.	0x02
<i>iInterface</i>	8/1	Index of string descriptor.	0x00

E.8 Endpoint Descriptor (Mouse)

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	0/1	Size of this descriptor in bytes.	0x07
<i>bDescriptorType</i>	1/1	Endpoint descriptor type (assigned by USB).	0x05
<i>bEndpointAddress</i>	2/1	The address of the endpoint.	10000010B
<i>bmAttributes</i>	3/1	This field describes the endpoint's attributes.	00000011B
<i>wMaxPacketSize</i>	4/2	Maximum packet size.	0x08
<i>bInterval</i>	6/1	Interval for polling endpoint for data transfers.	0x0A

E.9 HID Descriptor (Mouse)

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	0/1	Size of this descriptor in bytes.	0x09
<i>bDescriptorType</i>	1/1	HID descriptor type (assigned by USB).	0x01
<i>bcdHID</i>	2/2	HID Class Specification release number.	0x100
<i>bCountryCode</i>	4/1	Hardware target country.	0x00
<i>bNumDescriptors</i>	5/1	Number of HID class descriptors to follow.	0x01
<i>bDescriptorType</i>	6/1	Report descriptor type.	0x02
<i>wItemLength</i>	7/2	Total length of Report descriptor.	0x32

E.10 Report Descriptor (Mouse)

Item	Value (Hex)
Usage Page (Generic Desktop),	05 01
Usage (Mouse),	09 02
Collection (Application),	A1 01
Usage (Pointer),	09 01
Collection (Linked),	A1 00
Usage Page (Buttons),	05 09
Usage Minimum (01),	19 01
Usage Maximum (03),	29 03
Logical Minimum (0),	15 00
Logical Maximum (1),	25 01
Report Count (3),	95 03
Report Size (1),	75 01
Input (Data, Variable, Absolute), ;3 button bits	81 02
Report Count (1),	95 01
Report Size (5),	75 05
Input (Constant), ;5 bit padding	81 01
Usage Page (Generic Desktop),	05 01
Usage (X),	09 30
Usage (Y),	09 31
Logical Minimum (-127),	15 81
Logical Maximum (127),	25 7F
Report Size (8),	75 08
Report Count (2),	95 02
Input (Data, Variable, Relative), ;2 position bytes (X & Y)	81 06
End Collection,	C0
End Collection	C0

E.11 String Descriptors

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bLength</i>	00/01	Length of String descriptor in bytes.	0x04
<i>bDescriptorType</i>	01/01	Descriptor Type = String	0x03
<i>bString</i>	02/02	Array of LangID codes (in this case the 2-byte code for English).	0x0009
<i>bLength</i>	04/01	Length of String descriptor.	0x0A
<i>bDescriptorType</i>	05/01	Descriptor Type = String	0x03
<i>bString</i>	06/08	Manufacturer	ACME
<i>bLength</i>	14/01	Length of String descriptor.	0x22
<i>bDescriptorType</i>	15/01	Descriptor Type = String	0x03
<i>bString</i>	16/32	Product Locator Keyboard	Locator Keyboard
<i>bLength</i>	48/01	Length of String descriptor.	0x0E

Part	Offset/Size (Bytes)	Description	Sample Value
<i>bDescriptorType</i>	49/01	Descriptor Type = String	0x03
<i>bString</i>	50/12	Device Serial Number	ABC123

Note In this example, offset is used for the string index because the offset is always a small number (less than 256). Alternatively, each string could be given a sequential string index (0, 1, 2, 3...). Both implementations are functionally equivalent so long as the device responds appropriately to a string request.

Appendix F: BNF Grammar for the USB HID Descriptor

This grammar compiles cleanly under the MS-DOS version of Berkeley YACC (byacc.exe ver 1.9), and may be compiled with any YACC-compatible compiler.

```
ReportDescriptor      -> ItemList
                       ;

Item List             -> Items MainItem
                       | ItemList Items MainItem
                       ;

Main Item             -> Collection ItemList End Collection
                       | Input
                       | Output
                       | Feature
                       ;

Items                 -> GlobalItem
                       | LocalItem
                       | Set Delimiter(Open) LocalItemList Set Delimiter(Close)
                       | Items GlobalItem
                       | Items LocalItem
                       | Items Set Delimiter(Open) LocalItemList Set Delimiter(Close)
                       ;

LocalItem List        -> LocalItem
                       | LocalItemList LocalItem
                       ;

Global Item           -> Usage Page
                       | Logical Minimum
                       | Logical Maximum
                       | Physical Minimum
                       | Physical Maximum
                       | Unit
                       | Exponent
                       | Report Size
                       | Report Count
                       | Report ID
                       ;

Local Item            -> Usage
                       | Usage Minimum
                       | Usage Maximum
                       | Designator Index
                       | Designator Minimum
```

```
| Designator Maximum  
| String Index  
| String Minimum  
| String Maximum  
;
```

Appendix G: Keyboard Implementation

The boot and legacy protocols for keyboards in USB allow a system which is not USB-aware (such as PC BIOS or IEEE 1275 boot firmware) to support a USB **HID** class keyboard without fully supporting all required elements of USB. The Boot/Legacy Protocol does not limit keyboards to this behavior. Instead, it is anticipated that keyboards will support both the boot and legacy protocols and the full **HID**-compatible item-based protocols.

G.1 Purpose

This specification provides information to guide keyboard designers in making a USB Boot/Legacy keyboard. It provides information for developers of the system ROM so that they can use such a keyboard without fully parsing the **HID Report** descriptor. The motivation is that while the full **HID** class capability is enormously rich and complex, it is not feasible to implement the required **HID** class adjustable device driver in ROM. But, operator input may still be required for either boot or legacy support.

G.2 Management Overview

The **HID** Class specification provides for the implementation of self-describing input devices. A device's **HID** descriptors, including the **Report** descriptor, contain enough information for the operating system to understand the report protocol the device uses to send events like key presses.

Most USB devices will run with the support of some USB-aware operating system. The operating system can afford this level of complexity. In most systems, the ROM-based boot system cannot.

However, the ROM-based boot system usually requires some keyboard support to allow for system configuration, debugging, and other functions. Examples include the BIOS in PC-AT systems, and IEEE 1275 boot firmware in workstations. PC-AT systems running DOS have an additional problem, in that the BIOS must provide full keyboard support for DOS legacy applications required for system setup.

It is therefore necessary for the system to take keyboard input before the operating system loads. It soon follows that mouse support may also be necessary. To make this easier for the ROM developer, the **HID** specification defines a keyboard boot protocol and a mouse boot protocol. Since these protocols are predefined, the system can take the 8-byte packets and decode them directly. The boot system does not need to parse the **Report** descriptors to understand the packet.

G.3 Bootable Keyboard Requirements

In order to be a USB Bootable Keyboard, a keyboard should meet the following requirements:

- The bootable keyboard shall report keys in the format described in Appendix B of the **HID** Class specification.
- The bootable keyboard shall support the **Set_Idle** request.
- The bootable keyboard shall send data reports when the interrupt pipe is polled, even when there are no new key events. The **Set_Idle** request shall override this behavior as described in the **HID** Class specification.
- The bootable keyboard shall report “Keyboard ErrorRollOver” in all array fields when the number of non-modifier keys pressed exceeds the Report Count. The limit is six non-modifier keys for a Bootable Keyboard.
- The bootable keyboard shall report “Keyboard ErrorRollOver” in all array fields when combination of keys pressed cannot be accurately determined by the device, such as ghost key or rollover errors.
- The bootable keyboard shall not maintain CAPSLOCK, NUMLOCK, SCROLL LOCK, COMPOSE, or KANA LED states without explicit **Set_Report (Output)** requests from the system.
- The bootable keyboard shall support all usage codes of a standard 84-key keyboard. (See: Appendix A.3)
- The bootable keyboard shall support the **Set_Protocol** request.
- The bootable keyboard shall, on reset, return to the non- boot protocol which is described in its **Report** descriptor. That is, the **Report** descriptor for a bootable keyboard does not necessarily match the bootable protocol. The **Report** descriptor for a bootable keyboard is the non- boot protocol descriptor.
- On receipt of a **Get_Descriptor** request with *wValue* set to CONFIGURATION, the keyboard shall return the Configuration descriptor, all **Interface** descriptors, all **Endpoint** descriptors, and the **HID** descriptor. It shall not return the **HID Report** descriptor. The **HID** descriptor shall be interleaved with the **Interface** and **Endpoint** descriptors; that is, the order shall be:

```

Configuration descriptor (other Interface, Endpoint, and Vendor
Specific descriptors if required)
  Interface descriptor (with Subclass and Protocol specifying
  bootable keyboard)
    Endpoint descriptor (HID Interrupt Endpoint)
      HID descriptor (associated with this Endpoint)
        (other Interface, Endpoint, and Vendor Specific
        descriptors if required)

```

G.4 Keyboard: Non-USB Aware System Design Requirements

Following are the requirements for a BIOS, IEEE 1275 boot firmware, or other non-USB aware system to use a USB boot protocol keyboard:

- The system shall make no assumptions about the order of key presses from the order of keys within a single report. The order of key codes in array fields has no significance. Order determination is done by the host software comparing the contents of the previous report to the current report. If two or more keys are reported in one report, their order is indeterminate. Keyboards may buffer events that would have otherwise resulted in multiple events in a single report.
- The system shall implement typematic repeat rate and delay. The Boot keyboard has no capability to implement typematic repeat rate and delay. The system may use the device report rate and the number of reports to determine how long a key is being held down. Alternatively, the system may use its own clock or the **Set_Idle** request for the timing of these features.
- The system shall Maintain synchronization between LED states the Caps, Numlock, or Scroll Lock events. The system sets LED states by sending a 5-bit absolute report to the keyboard via a **Set_Report** (specifying **Output** report) request.
- The system shall issue a **Set_Protocol** request to the keyboard after Configuring the keyboard device.
- The system shall disregard the value of the second byte in the 8-byte keyboard data packet. This byte is available for system-specific extensions; however, there is no guarantee that any use of the second byte will be portable to a non-specific system. It is therefore likely to be limited to use as a notebook keyboard feature extension, where the notebook is built n to the system and not able to be moved to a generic platform.

G.5 Keyboard: Using the Keyboard Boot Protocol

This section explains some of the detail behind the requirements listed in Appendix G.4.

To use the boot protocol, the system should do the following:

- Select a Configuration which includes a **bInterfaceSubClass** of 1, “Boot Interface Subclass,” and a **bInterfaceProtocol** of 1, “Keyboard”.
- Do a **Set_Protocol** to ensure the device is in boot mode. By default, the device comes up in non-boot mode (must read the **Report** descriptor to know the protocol), so this step allows the system to put the device into the predefined boot protocol mode.

- On receipt of an 8-byte report on the Interrupt endpoint, the system must look at the modifier key bits (Byte 0, bits 7–0) to determine if any of the SHIFT, CTRL, ALT, or GUI keys has changed state since the last report. The system must also look at the six keycode bytes to see if any of the non-modifier keys has changed state since the last report.
- If a non-modifier key has changed state, the system must translate the keycode sent in the **Report** to a system-recognized key event.
- This remapping can be accomplished through a look-up table. The keycode is actually an index, but for the system developer the distinction does not matter. The value sent in the bootable key report is identical to the value in the Usage Index. For example, if the report contains the following then by looking up the Usage Index in the Key Usage Table, the 04h is the A key, the 3Ah is the F1 key, and the 5Dh is the numeric keypad 5 key.

Byte	Value
Byte 0	00000000b
Byte 1	00000000b
Byte 2	04h
Byte 3	3Ah
Byte 4	5Dh
Byte 5	00h
Byte 6	00h
Byte 7	00h

Important It must be stressed that this is a carefully arranged exception to the rule that **Usages** are not sent in a **HID** report. In the bootable case, the keycode table has been written specifically so that the **Usage** is equal to the Logical Index which is reported.

For example, assume a certain 10-key keypad does not use the boot protocol. Therefore, it may not declare itself to be a bootable keyboard. It might supply the following **Report** descriptor, an example of a non-bootable 17-key numeric keypad:

```
Usage Page (Generic Desktop),
Usage (Keyboard),
Report Count (0),
Collection (Application),
Usage Page(Key Codes),
Usage Minimum(54h),
Usage Maximum(63h)
Logical Minimum (1),
Logical Maximum (17),
Report Size (8),
```

```
Report Count (3)
Input (Data, Array),
End Collection
```

The **Usages** come from the same Key Code Usage Page, but because the Logical Minimum, Logical Maximum, Usage Minimum and Usage Maximum values are different, the bytes in the report no longer line up with the **Usages** in the Key Code Usage Page. To indicate that the keypad ‘5’ is down in this example, the report from this device would be as follows.

Byte	Value
0	0Bh
1	00h
2	00h

The 0Bh is the Index into the list of **Usages** declared by the above descriptor. The list of declared **Usages** starts with 53h, which is the Usage for “Keypad Numlock and Clear”. The eleventh element in this list is “Keypad 5”, so the report includes an entry with 0Bh.

This two step de-referencing is necessary for a non-boot device. In the general case, the Usages required may not start at 1, may not be a continuous list, and may use two or more **Usage Pages**.

However, the boot protocol was designed to be both compatible with the **HID Report** descriptor parts, and to eliminate the two-step de-referencing for this special case. The operating system should read the **HID Report** descriptor for the device protocol. The ROM-based system may use the boot protocol after issuing the **Set_Protocol** request.

Appendix H: Glossary Definitions

This appendix defines terms used throughout this document. For additional terms that pertain to the USB, see Chapter 2, “Terms and Abbreviations,” in the USB Specification.

Array

A series of data fields each containing an index that corresponds to an activated control. Banks of buttons or keys are reported in array items.

Button bitmap

A series of 1-bit fields, each representing the on/off state of a button. Buttons can be reported in either an array or a button bitmap.

Class

A USB device is organized into classifications such as **HID**, audio, or other-based on the device’s features, supported requests, and data protocol.

Collection

A collection is a meaningful grouping of **Input**, **Output**, and **Feature** items—for example, mouse, keyboard, joystick, and pointer. A pointer **Collection** contains items for x and y position data and button data. The **Collection** and **End Collection** items are used to delineate collections.

Control

A sink or source of a data field—for example, an LED is a sink or destination for data. A button is a source of data.

Control pipe

The default pipe used for bi-directional communication of data as well as for device requests.

Data item

An item that adds fields to a report. For example, **Input**, **Output**, and **Feature** items are all data.

Data phase

Part of a device’s response to a request.

Descriptor

Stored in segments within the ROM of a USB device, the device descriptor identifies the class associated with the device—for example, **HID**, audio, or other.

Descriptor sets

A group of descriptors is called a descriptor set.. Descriptor sets include **HID**, **Item**, and **String**.

Device class

A method of organizing common functions and protocols for devices that serve similar functions—for example, communication, audio, display, and so on.

Device descriptor

Packet of information that describes the device—for example, the vendor, product ID, firmware version, and so on.

Endpoint descriptor

HID descriptor that identifies which other descriptors are present and identifies their sizes.

Feature control

Feature controls affect the behavior of the device or report the state of the device. Unlike input or output data, feature data is intended for use by device configuration utilities and not applications. For example, the value for the repeat rate of a particular key could be a feature control. **HID** feature controls are unrelated to features discussed in Chapter 9 of the USB Specification.

Feature item

Adds data fields to a Feature report.

Field

A discrete section of data within a report.

Frame

The smallest unit of time on the Universal Serial Bus (USB); equal to 1 millisecond.

HID (Human Interface Device)

Acronym specifying either a specific class of devices or the type of device known as Human Interface Devices (**HID**) or **HID** class devices—for example, a data glove. In this document, “**HID** class” is synonymous with a device of type: human interface.

HID class

The classification of USB devices associated with human interface devices (**HID**).

HID class device

A device of type: human interface and classified as such.

HID descriptor

Information about a USB device is stored in segments of its ROM (read-only memory). These segments are called descriptors.

Host

A computer with a USB port, as opposed to a device plugged into it.

Hub

A USB device containing one or more USB ports.

Input item

Adds one or more data fields to an input report. Input controls are a source of data intended for applications—for example, x and y data.

Interface descriptor

The class field of this descriptor defines this device as a **HID** class device.

Interrupt pipe

The pipe used to transfer unrequested data from the device to the host.

Item

A component of A **Report** descriptor that represents a piece of information about the device. The first part of an item, called the item tag, identifies the kind of information an item provides. Also, referred to generically as **Report** items.

Included are three categories of items: **Main**, **Global**, and **Local**. Each type of item is defined by its tag. Also referred to as **Main** item tag, **Global** item tag, and **Local** item tag.

Item parser

The part of the **HID** class driver that reads and interprets the items in the **Report** descriptor.

Logical units

The value the device returns for Logical Minimum and Logical Maximum. See Physical units.

LSB

Least Significant Byte

Message pipe

Another name for the **Control** pipe.

NAK

The value returned when a request has been sent to the device and the device is not prepared to respond.

Nibble

A half of a byte; 4 bits.

Non-USB aware

An operating system, program loader, or boot subsystem which does not support USB per the core and device class specifications. Examples include PC-AT BIOS and IEEE 1275 boot firmware.

Null

No value, or zero, depending upon context.

Output item

Adds one or more data fields to an output report. Output controls are a destination for data from applications—for example, LEDs.

Packets

A USB unit of information: Multiple packets make up a transaction, multiple transactions make up a transfer report.

Part

Document convention used to define bit attributes.

Physical Descriptor

Determines which body part is used for a control or collection. Each **Physical** descriptor consists of the following three fields: **Designator**, **Qualifier** and **Effort**.

Physical units

The logical value with a unit parameter applied to it. See Logical units.

Pipes

Pipes are different ways of transmitting data between a driver and a device. There are different types of pipes depending on the type of encoding or requesting that you want to do. For example, all devices have **Control** pipe by default. The **Control** pipe is used for message-type data. A device may have one or more **Interrupt** pipes. An **Interrupt** pipe is used for stream-type data. Other types of pipes include **Bulk** and **Isochronous**. These two types of pipes are not used by **HID** class devices and are therefore not defined for use within this specification.

Report

A data structure returned by the device to the host (or vice versa). Some devices may have multiple report structures, each representing only a few items. For example, a keyboard with an integrated pointing device could report key data independently of pointing data on the same endpoint.

Report descriptor

Specifies fields of data transferred between a device and a driver.

Set

A group of descriptors—for example, a descriptor set.

Stream pipe

Isochronous pipe used to transmit data.

String descriptor

A table of text used by one or more descriptors.

Tag

Part of a **Report** descriptor that supplies information about the item, such as its usage.

Terminating items

An item within a descriptor. For example, **Push**, **Pop**, and **Item** are terminating items. When the item parser within the **HID** class driver locates a terminating item, the contents of the item state table are moved.

Transaction

A device may send or receive a transaction every USB frame (1 millisecond). A transaction may be made up of multiple packets (token, data, handshake) but is limited in size to 8 bytes for low-speed devices and 64 bytes for high-speed devices.

Transfer

One or more transactions creating a set of data that is meaningful to the device—for example, **Input**, **Output**, and **Feature** reports. In this document, a transfer is synonymous with a report.

Usage

What items are actually measuring as well as the vendor's suggested use for specific items.

USB Boot Device

Device is USB **HID** “Boot/Legacy” compliant and Reports its ability to use the boot protocol, or report format, defined in the **HID** class specification for input devices such as keyboards or mouse devices.

Variable

A data field containing a ranged value for a specific control. Any control reporting more than on/off needs to use a variable item.

Vendor

Device manufacturer.

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