Universal Serial Bus (USB)

Device Class Definition for Human Interface Devices (HID)

Firmware Specification—5/27/01

Version 1.11

Please send comments via electronic mail to:
hidcomments@usb.org

Contents

1. Preface

1.1 Intellectual Property Disclaimer

1.2 Contributors

While many people contributed to this document, only one contributor is listed from each organization.

Company	Contact
Alps	Mike Bergman
Cybernet	Tom Peurach
DEC	Tom Schmidt
Intel	Steve McGowan
Key Tronic Corporation	Jodi Crowe
LCS/Telegraphics	Robert Dezmelyk
Logitech	Remy Zimmermann
Microsoft Corporation	Mike Van Flandern
NCR	Bob Nathan
Sun Microsystems	Mike Davis
ThrustMaster	Joe Rayhawk

1.3 Scope of this Revision

This version 1.11 release incorporates all review requests approved at it's release date that apply to the USB Device Class Definition for Human Interface Devices (**HID** Specification).

1.4 Revision History

Version	Release date	Description
1.11	6/27/01	1.11 Release. Incorporated HID review requests: 39, 53, 60, 61, and 62.
1.1	4/7/99	1.1 Release. Incorporated HID review requests: 18, 19, 20, 21, 22, 23, 25, 26, 28, 29, 30, 32, 35 and 52. Removed Usage Table sections. These can be found in the *Universal Serial Bus HID Usage Tables* document.
1.0	1/30/96	1.0 Release.

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.
BValue	Italicized letters or words indicate placeholders for information supplied by the developer.
bValue, *bcdName*, *wOther*	Placeholder prefixes such as '*b'*, '*bcd'*, and '*w'* are used to denote placeholder type. For example: *b* bits or bytes; dependent on context *bcd* binary-coded decimal *bm* bitmap *d* descriptor *i* index *w* word
[*bValue***]**	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. 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..” See Section 2.3: Related Documents.

2.2 Purpose

This document is intended to supplement the USB Specification and provide **HID** manufacturers with the 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 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:

Name	Comment
Universal Serial Bus (USB) Specification, Version 1.0	In particular, see Chapter 9, “USB Device Framework.”
USB Class Specification for Legacy Software	
USB HID Usage Supplement	A detailed extension of the usages listed in Appendix A.
USB Physical Interface Device (PID) Specification	
USB Audio Device Class	

The most current information is maintained at the following site on the World Wide Web: http://www.usb.org

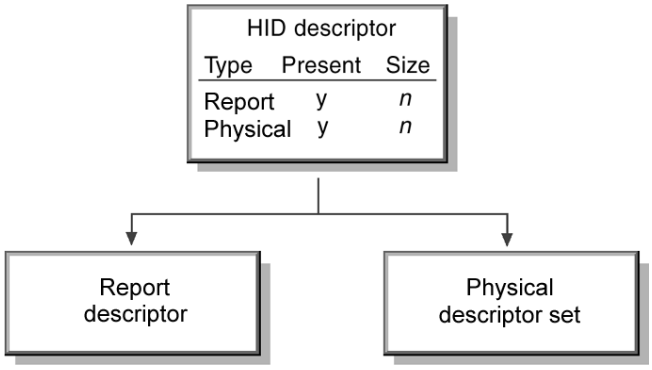
3. Management Overview

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.

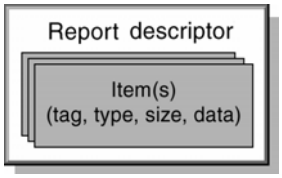
A USB/HID class device uses a corresponding **HID** class driver to retrieve and route all data.

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 HID class descriptors are present and indicates their sizes. For example, **Report** and **Physical Descriptors**.



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

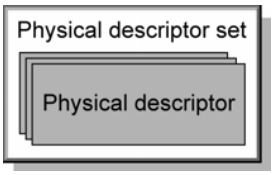


For example, a **Report** descriptor defines items that describe a position or button state. Item information is used to:

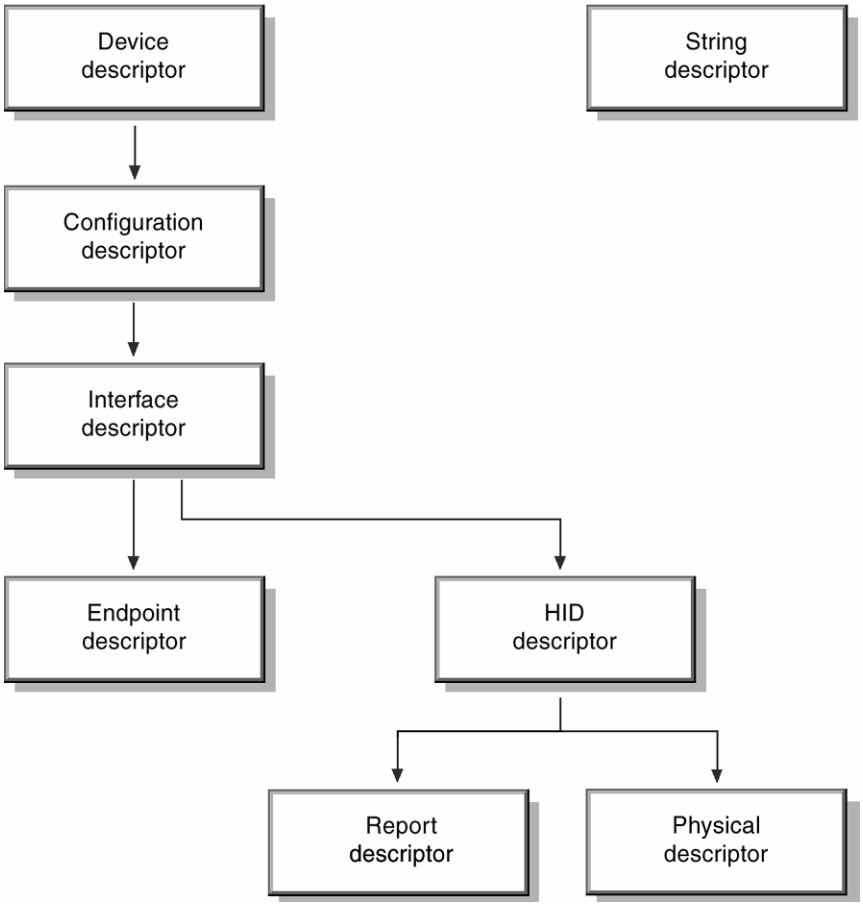
- Determine where to route input—for example, send input to mouse or joystick API.
- Allow software to assign functionality to input—for example, use joystick input to position a tank.

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.

Physical descriptor sets are optional descriptors which provide information about the part or parts of the human body used to activate the controls on a device.



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



The rest of this specification documents the 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. 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.

The USB Core Specification defines the HID class code. The *bInterfaceClass* member of an Interface descriptor is always 3 for HID class devices.

See Also

The Audio Class Specification defines audio device transport requirements in greater detail. 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.

The *bInterfaceSubClass* member declares whether a device supports a boot interface, otherwise it is 0.

Subclass Codes

Subclass Code	Description
0	No Subclass
1	Boot Interface Subclass
2 - 255	Reserved

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 Protocols

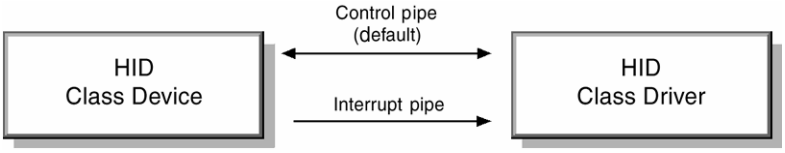
A variety of protocols are supported HID devices. The *bInterfaceProtocol* member of an Interface descriptor only has meaning if the *bInterfaceSubClass* member declares that the device supports a boot interface, otherwise it is 0.

Protocol Codes

Protocol Code	Description
0	None
1	Keyboard
2	Mouse
3 - 255	Reserved

4.4 Interfaces

A **HID** class device communicates with the **HID** class driver using either the **Control** (default) pipe or an **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 are used for:

- Receiving asynchronous (unrequested) data from the device.
- Transmitting low latency data to the device.

The Interrupt Out pipe is optional. If a device declares an Interrupt Out endpoint then Output reports are transmitted by the host to the device through the Interrupt Out endpoint. If no Interrupt Out endpoint is declared then Output reports are transmitted to a device through the Control endpoint, using Set_Report(Output) requests.

Note **Endpoint 0** is a **Control** pipe always present in USB devices. Therefore, only the **Interrupt In** pipe is described for the **Interface** descriptor using an **Endpoint** descriptor. In fact, several **Interface** descriptors may share **Endpoint 0**. An **Interrupt Out** pipe is optional and requires an additional **Endpoint** descriptor if declared.

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

See Also

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

4.5 Device Limitations

This specification applies to both high-speed and low-speed **HID** class devices. Each type of device possesses various limitations, as defined in Chapter 5 of the Universal Serial Bus Specification.

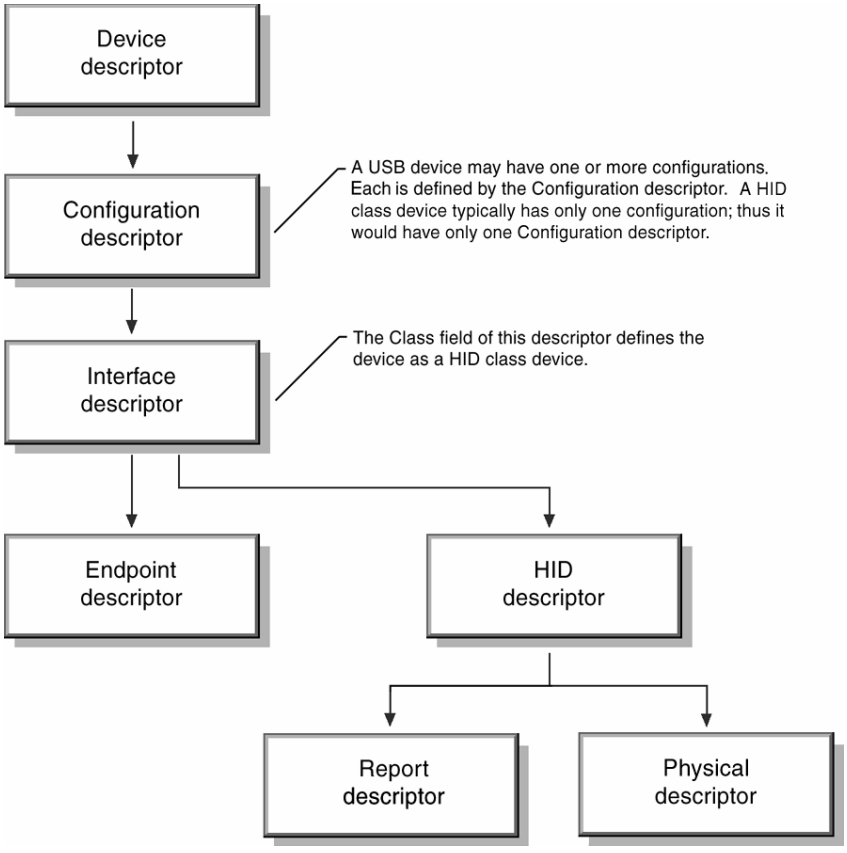
5. Operational Model

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**.

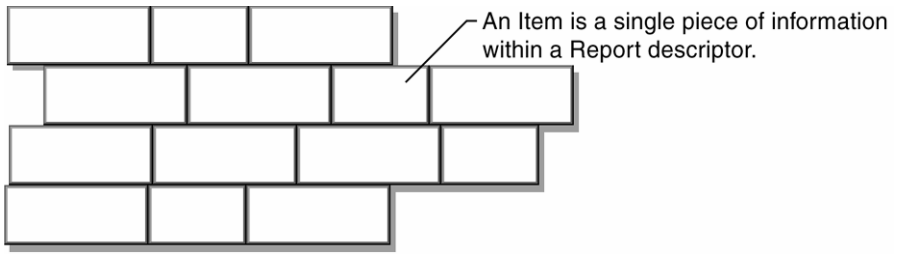
Note The *bDeviceClass* and *bDeviceSubClass* fields in the Device Descriptor should not be used to identify a device as belonging to the HID class. Instead use the *bInterfaceClass* and *bInterfaceSubClass* fields in the Interface descriptor.

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. For methods of descriptor retrieval, see Section 7: Requests

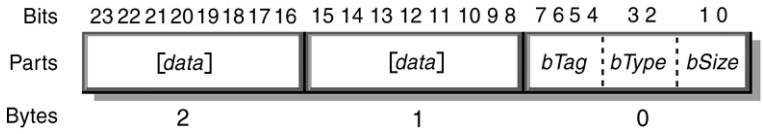
5.2 Report Descriptors

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**.

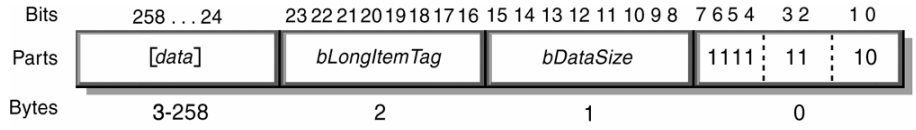


5.3 Generic Item Format

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.



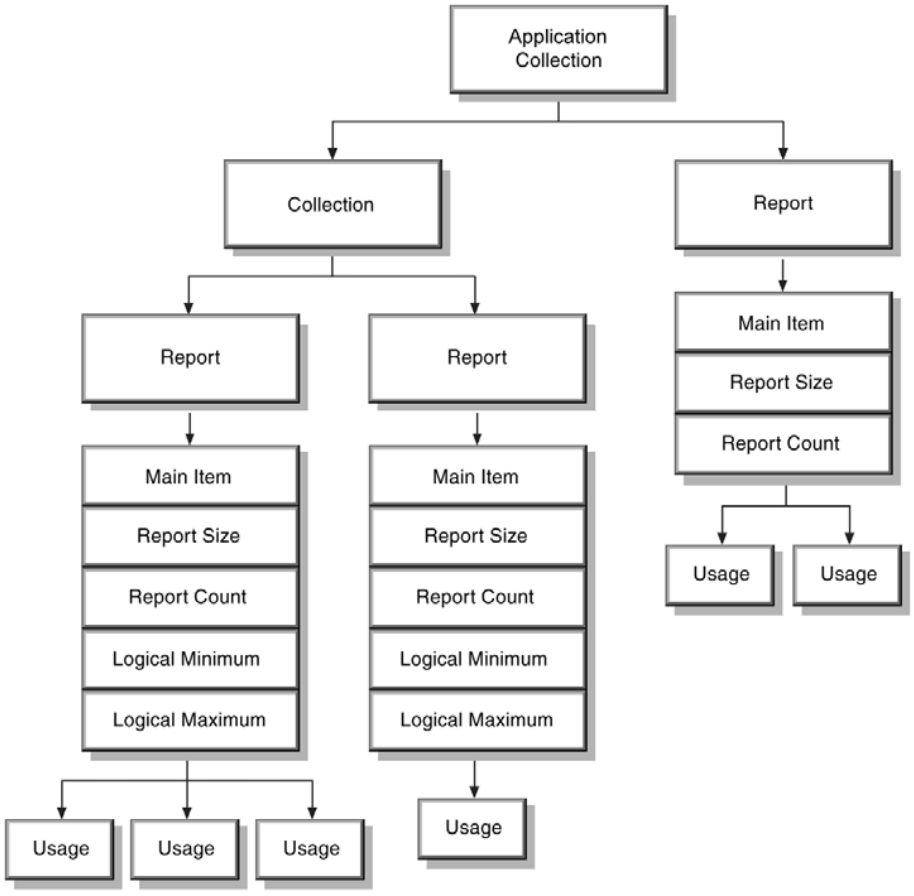
An item may include optional item data. The size of the data portion of an item is determined by its fundamental type. There are two basic types of items: short items and long items. If the item is a short item, its optional data size may be 0, 1, 2, or 4 bytes. If the item is a long item, its *bSize* 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 (10^{-3} meters) on the stack. The next item changes the item state table to units of meters (10^{0} meters).

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.

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.

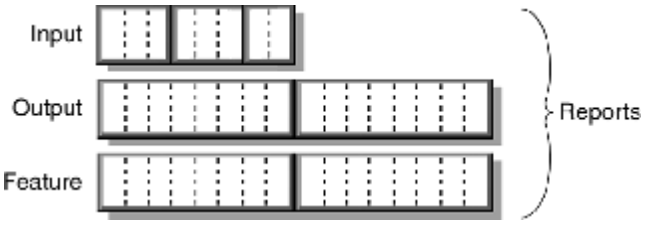
A **Usage** is interpreted as a 32 bit unsigned value where the high order 16 bits defines the **Usage Page** and the low order 16 bits defines a **Usage ID**. Usage IDs are used to select individual Usage on a Usage Page.

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 In** pipe. **Feature** and **Output** reports must be initiated by the host via the **Control** pipe or an optional **Interrupt Out** 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.

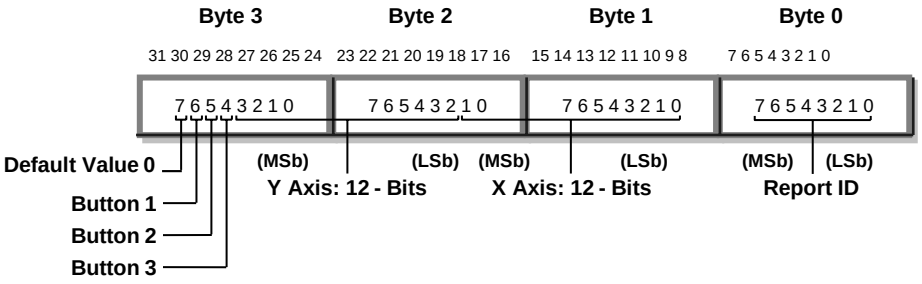
See Also

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

5.8 Format of Multibyte Numeric Values

Multibyte numeric values in reports are represented in little-endian format, with the least significant byte at the lowest address. The Logical Minimum and Logical Maximum values identify the range of values that will be found in a report. If Logical Minimum and Logical Maximum are both positive values then a sign bit is unnecessary in the report field and the contents of a field can be assumed to be an unsigned value. 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

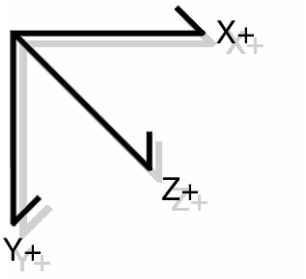


representation of a long integer value.

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.

5.10 Null Values

HID class devices support the ability to ignore selected fields in a report at run-time. This is accomplished by declaring bit field in a report that is capable of containing a range of values larger than those actually generated by the control. If the host or the device receives an out-of-range value then the current value for the respective control will not be modified.

A hardware developer must carefully evaluate the controls in an individual report to determine how an application on the host will use them. If there are any situations in which an application will not modify a particular field every time the report is sent to the device, then the field should provide a Null value. With Null values, the host can initialize all fields in a report that it does not wish to modify to their null (out-of-range) value and set the fields that it wishes to modify to valid (in-range) values.

If an 8-bit field is declared and the range of valid values is 0 to 0x7F then any value between 0x80 and 0xFF will be considered out of range and ignored when received. The initialization of null values in a report is much easier if they are all the same.

NOTE: It is *highly recommended* that 0 be included in the set of Null values so that report buffers can simply be set to zero to establish the “don’t care” state for all fields.

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
bLength	0/1	Numeric expression that is the total size of the HID descriptor.
bDescriptorType	1/1	Constant name specifying type of HID descriptor.
bcdHID	2/2	Numeric expression identifying the HID Class Specification release.
bCountryCode	4/1	Numeric expression identifying country code of the localized hardware.
bNumDescriptors	5/1	Numeric expression specifying the number of class descriptors (always at least one i.e. Report descriptor.)
bDescriptorType	6/1	Constant name identifying type of class descriptor. See Section 7.1.2: Set_Descriptor Request for a table of class descriptor constants.
wDescriptorLength	7/2	Numeric expression that is the total size of the Report descriptor.
[*bDescriptorType*]...	9/1	Constant name specifying type of optional descriptor.
[*wDescriptorLength*]...	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 *bNumDescriptors* identifies the number of additional class specific descriptors present. This number must be at least one (1) as a **Report** descriptor will always be present. The remainder of the **HID** descriptor has the length and type of each additional class descriptor.
- The value *bCountryCode* 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 (decimal)	Country	Code (decimal)	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
10	Greek	28	Swiss/German
11	Hebrew	29	Switzerland
12	Hungary	30	Taiwan
13	International (ISO)	31	Turkish-Q
14	Italian	32	UK
15	Japan (Katakana)	33	US
16	Korean	34	Yugoslavia
17	Latin American	35	Turkish-F
		36-255	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.

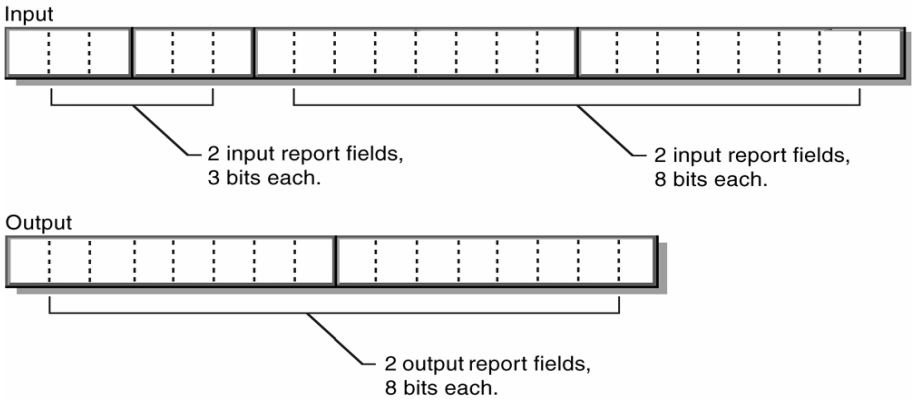
- **Collection** item tag: A meaningful grouping of **Input**, **Output**, and **Feature** items—for example, mouse, keyboard, joystick, and pointer.
- **End Collection** item tag: A terminating item used to specify the end of a collection of items.

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 (details omitted for brevity):

```
Report Size (3)
Report Count (2)
Input
Report Size (8)
Input
Output
```

The item parser interprets the **Report** descriptor items above and creates the following reports (the LSB is on the left):



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 (Physical),               ;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
```

6.2.2.1 Items Types and Tags

All items contain a 1-byte prefix which denotes the basic type of the item. The **HID** class defines two basic formats for items:

- Short items: 1–5 bytes total length; used for the most commonly occurring items. A short item typically contains 1 or 0 bytes of optional data.
- Long items: 3–258 bytes in length; used for items that require larger data structures for parts.

Note This specification defines only items that use the short format.

The two item formats should not be confused with types of items such as **Main**, **Global**, and **Local**.

See Also

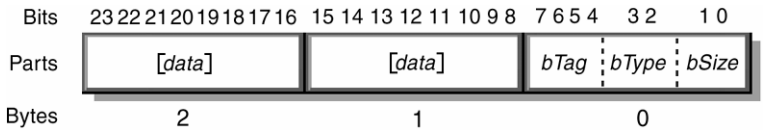
For overview information, see Section 5.3: Generic Item Format.

6.2.2.2 Short Items

Description

The short item format packs the item size, type, and tag into the first byte. The first byte may be followed by 0, 1, 2, or 4 optional data bytes depending on the size of the data.

Parts



Part	Description
bSize	Numeric expression specifying size of data: 0 = 0 bytes 1 = 1 byte 2 = 2 bytes 3 = 4 bytes
bType	Numeric expression identifying type of item where: 0 = Main 1 = Global 2 = Local 3 = Reserved
bTag	Numeric expression specifying the function of the item.
[*data*]	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.

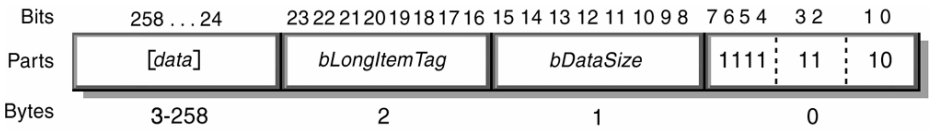
- If a large data item is expected, it can still be abbreviated if all of its high-order bits are zero. For example, a 32-bit part in which bytes 1, 2, and 3 are all 0 can be abbreviated as a single byte.
- There are three categories of short item tags: **Main**, **Global**, and **Local**. The item type (*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
bSize	Numeric expression specifying total size of item where size is 10 (2 bytes); denotes item type as long.
bType	Numeric expression identifying type of item where 3 = Reserved
bTag	Numeric expression specifying the function of the item; always 1111.
[*bDataSize*]	Size of long item data.
[*bLongItemTag*]	Long item tag.
[*data*]	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 (*nn* represents size value)	Valid Data	
Input	1000 00 *nn*	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	{No Null position (0) | Null state(1)}
		Bit 7	Reserved (0)
		Bit 8	{Bit Field (0) | Buffered Bytes (1)}
		Bit 31-9	Reserved (0)
Output	1001 00 *nn*	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	{No Null position (0) | Null state(1)}
		Bit 7	{Non Volatile (0) | Volatile (1)}
		Bit 8	{Bit Field (0) | Buffered Bytes (1)}
		Bit 31-9	Reserved (0)
Feature	1011 00 *nn*	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	{No Null position (0) | Null state(1)}
		Bit 7	{Non Volatile (0) | Volatile (1)}
		Bit 8	{Bit Field (0) | Buffered Bytes (1)}
		Bit 31-9	Reserved (0)
Collection	1010 00 *nn*	0x00	Physical (group of axes)
		0x01	Application (mouse, keyboard)
		0x02	Logical (interrelated data)
		0x03	Report
		0x04	Named Array
		0x05	Usage Switch
		0x06	Usage Modifier
		0x07-0x7F	Reserved
		0x80-0xFF	Vendor-defined
End Collection	1100 00 *nn*	Not applicable. Closes an item collection.	

Main item tag	One-Byte Prefix (*nn* represents size value)	Valid Data
Reserved	1101 00 *nn* to 1111 00 *nn*	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. Data indicates the item is defining report fields that contain modifiable device data. Constant indicates the item is a static read-only field in a report and cannot be modified (written) by the host.
1	Array | Variable	0 | 1	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). 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 out-of range value in and array field is considered no controls asserted. 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 + 1).
2	Absolute | Relative	0 | 1	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.

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	No Null Position | Null State	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.
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.

Bit	Part	Value	Description
9 - 31	Reserved	0	Reserved for future use.

Remarks

- 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.
- The value returned by an **Array** item is an index so it is recommended that:
  1) An Array field returns a 0 value when no controls in the array are asserted.
  2) The Logical Minimum equals 1.
  3) The Logical Maximum equal the number of elements in the array.
- **Input** items define input reports accessible via the **Control** pipe with a **Get_Report (Input)** request.
- **Input** type reports are also sent at the polling rate via the **Interrupt In** 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 a **Set_Report (Output)** command.
- **Output** type reports can optionally be sent via an **Interrupt Out** pipe.

  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
Physical	0x00	A physical collection is used for a set of data items that represent data points collected at one geometric point. This is useful for sensing devices which may need to associate sets of measured or sensed data with a single point. It does not indicate that a set of data values comes from one device, such as a keyboard. In the case of device which reports the position of multiple sensors, physical collections are used to show which data comes from each separate sensor.
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 (at least one report ID per application).
Logical	0x02	A logical collection is used when a set of data items form a composite data structure. An example of this is the association between a data buffer and a byte count of the data. The collection establishes the link between the count and the buffer.
Report	0x03	Defines a logical collection that wraps all the fields in a report. A unique report ID will be contained in this collection. An application can easily determine whether a device supports a certain function. Note that any valid Report ID value can be declared for a Report collection.
Named Array	0x04	A named array is a logical collection contains an array of selector usages. For a given function the set of selectors used by similar devices may vary. The naming of fields is common practice when documenting hardware registers. To determine whether a device supports a particular function like Status, an application might have to query for several known Status selector usages before it could determine whether the device supported Status. The Named Array usages allows the Array field that contains the selectors to be named, thus the application only needs to query for the Status usage to determine that a device supports status information.
Usage Switch	0x05	A Usage Switch is a logical collection that modifies the meaning of the usages that it contains. This collection type indicates to an application that the usages found in this collection must be special cased. For instance, rather than declaring a usage on the LED page for every possible function, an Indicator usage can be applied to a Usage Switch collection and the standard usages defined in that collection can now be identified as indicators for a function rather than the function itself. Note that this collection type is not used for the labeling Ordinal collections, a Logical collection type is used for that.

Type of collection	Value	Description
Usage Modifier	0x06	Modifies the meaning of the usage attached to the encompassing collection. A usage typically defines a single operating mode for a control. The usage modifier allows the operating mode of a control to be extended. For instance, an LED is typically on or off. For particular states a device may want a generic method of blinking or choosing the color of a standard LED. Attaching the LED usage to a Usage Modifier collection will indicate to an application that the usage supports a new operating mode.
Reserved	0x07 - 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, a **Usage** item tag must be associated with any collection (such as a mouse or throttle). **Collection** items may be nested, and they are always optional, except for the top-level application collection.
- If an unknown Vendor-defined collection type is encountered, then an application must ignore all main items declared in that collection. Note that global items declared in that collection will effect the state table.
- If an unknown usage is attached to a known collection type then the contents of that collection should be ignored. Note that global items declared in that collection will effect the state table.
- String and Physical indices, as well as delimiters may be associated with collections.

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

Global item tag	One-Byte Prefix (*nn* represents size value)	Description
Usage Page	0000 01 *nn*	Unsigned integer specifying the current Usage Page. Since a usage are 32 bit values, Usage Page items can be used to conserve space in a report descriptor by setting the high order 16 bits of a subsequent usages. Any usage that follows which is defines 16 bits or less is interpreted as a Usage ID and concatenated with the Usage Page to form a 32 bit Usage.
Logical Minimum	0001 01 *nn*	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	0010 01 *nn*	Extent value in logical units. This is the maximum value that a variable or array item will report.
Physical Minimum	0011 01 *nn*	Minimum value for the physical extent of a variable item. This represents the Logical Minimum with units applied to it.
Physical Maximum	0100 01 *nn*	Maximum value for the physical extent of a variable item.
Unit Exponent	0101 01 *nn*	Value of the unit exponent in base 10. See the table later in this section for more information.
Unit	0110 01 *nn*	Unit values.
Report Size	0111 01 *nn*	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 (*nn* represents size value)	Description
Report ID	1000 01 *nn*	Unsigned value that 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. 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 in pipe. And allows the device to distinguish different types of reports arriving over a single interrupt out pipe. Report ID zero is reserved and should not be used.
Report Count	1001 01 *nn*	Unsigned integer specifying the 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	1010 01 *nn*	Places a copy of the global item state table on the stack.
Pop	1011 01 *nn*	Replaces the item state table with the top structure from the stack.
Reserved	1100 01 *nn* to 1111 01 *nn*	Range reserved for future use.

See Also

For a list of **Usage Page** tags, see the HID Usage Table document.

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 by allowing the report value to be offset and scaled. For example, a thermometer might have logical extents of 0 and 999 but physical extents of 32 and 212 degrees.The resolution can be determined **with** the following algorithm:

```
if  ((Physical Maximum == UNDEFINED)
  || (Physical Minimum == UNDEFINED)
  || ((Physical Maximum == 0) && (Physical Minimum == 0)))
{
  Physical Maximum = Logical Maximum;
  Physical Minimum = Logical Minimum;
}

If (Unit Exponent == UNDEFINED)
  Unit Exponent = 0;

Resolution = (Logical Maximum – Logical Minimum) /
((Physical Maximum – Physical Minimum)  *
(10 Unit Exponent))
```

When linearly parsing a report descriptor, the global state values of Unit Exponent, Physical Minimum and Physical Maximum are considered to be in an “UNDEFINED” state until they are declared.

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:

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

- 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 0xF is vendor-

defined.

- If both the **Logical Minimum** and **Logical Maximum** extents are defined as positive values (0 or greater) then the report field can be assumed to be an unsigned value. Otherwise, all integer values are signed values represented in 2's complement format.
- Until **Physical Minimum** and **Physical Maximum** are declared in a report descriptor they are assumed by the HID parser to be equal to **Logical Minimum** and **Logical Maximum**, respectively. After declaring them to so that they can applied to a (Input, Output or Feature) main item they continue to effect all subsequent main items. If both the **Physical Minimum** and **Physical Maximum** extents are equal to 0 then they will revert to their default interpretation.
- 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:

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

  The **Unit** exponent would be 7 because a joule is composed of kilograms (1 kg equals 10^3 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						
	5 (i)	4 (τ)	3 (t)	2 (m)	1 (l)	0 (sys)	Code
Distance (cm)	0	0	0	0	1	1	x0011
Mass (g)	0	0	0	1	0	1	x0101
Time (s)	0	0	1	0	0	1	x1001
Velocity (cm/s)	0	0	-1	0	1	1	xF011
Momentum	0	0	-1	1	1	1	xF111
Acceleration	0	0	-2	0	1	1	xE011
Force	0	0	-2	1	1	1	xE111
Energy	0	0	-2	1	2	1	xE121
Angular Acceleration	0	0	-2	0	1	2	xE012
Voltage	-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),
...
```

- If **Report IDs** are used, then a **Report ID** must be declared prior to the first Input, Output, or Feature main item declaration in a report descriptor.
- The same **Report ID** value can be encountered more than once in a report descriptor. Subsequently declared Input, Output, or Feature main items will be found in the respective ID/Type (Input, Output, or Feature) report.

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 (*nn* represents size value)	Description
Usage	0000 10 *nn*	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	0001 10 *nn*	Defines the starting usage associated with an array or bitmap.
Usage Maximum	0010 10 *nn*	Defines the ending usage associated with an array or bitmap.
Designator Index	0011 10 *nn*	Determines the body part used for a control. Index points to a designator in the Physical descriptor.
Designator Minimum	0100 10 *nn*	Defines the index of the starting designator associated with an array or bitmap.
Designator Maximum	0101 10 *nn*	Defines the index of the ending designator associated with an array or bitmap.
String Index	0111 10 *nn*	String index for a String descriptor; allows a string to be associated with a particular item or control.
String Minimum	1000 10 *nn*	Specifies the first string index when assigning a group of sequential strings to controls in an array or bitmap.
String Maximum	1001 10 *nn*	Specifies the last string index when assigning a group of sequential strings to controls in an array or bitmap.
Delimiter	1010 10 *nn*	Defines the beginning or end of a set of local items (1 = open set, 0 = close set).
Reserved	1010 10 *nn* to 1111 10 *nn*	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**).
- All **Local** items are unsigned integers.

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 101.
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.

- If a **Usage Minimum** is declared as and extended usage then the associated **Usage Maximum** must also be declared as an extended usage.
- Interpretation of **Usage**, **Usage Minimum** or **Usage Maximum** items vary as a function of the item's *bSize* field. If the bSize field = 3 then the item is interpreted as a 32 bit unsigned value where the high order 16 bits defines the **Usage Page** and the low order 16 bits defines the **Usage ID**. 32 bit usage items that define both the Usage Page and Usage ID are often referred to as "Extended" Usages.

  If the bSize field = 1 or 2 then the **Usage** is interpreted as an unsigned value that selects a **Usage ID** on the currently defined Usage Page. When the parser encounters a main item it concatenates the last declared Usage Page with a Usage to form a complete usage value. Extended usages can be used to override the currently defined Usage Page for individual usages.
-

- Two or more alternative usages may be associated with a control by simply bracketing them with **Delimiter** items. Delimiters allow aliases to be defined for a control so that an application can access it in more than one way. The usages that form a delimited set are organized in order of preference, where the first usage declared is the most preferred usage for the control.

  HID parsers must handle **Delimiters** however, the support for the alternative usages that they define is optional. Usages other than the first (most preferred) usage defined may not be made accessible by system software.

- **Delimiters** cannot be used when defining usages that apply to Application Collections or Array items.

6.2.2.9 Padding

Reports can be padded to byte-align fields by declaring the appropriately sized main item and not declaring a usage for the main item.

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 **Physical Descriptors** are grouped into sets. **Designator Index** items 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 ORed 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 descriptor set 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 descriptor set 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.

Descriptor set 0 is a special descriptor set that specifies the number of additional descriptor sets, and also the number of **Physical Descriptors** in each set.

Part	Offset/Size (Bytes)	Description
bNumber	0/1	Numeric expression specifying the number of **Physical Descriptor** sets. Do not include Physical Descriptor 0 itself in this number.
bLength	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 descriptor set specified in the request *wValue* low byte. A descriptor set consists of a header followed by one or more **Physical Descriptors**.

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

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

Remarks

- The **Bias** field indicates which hand the descriptor 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 descriptor sets with a left-handed **Bias**.

- The **Preference** field indicates whether the descriptor set 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 descriptor sets.
- **Physical Descriptors** within a descriptor set are referenced by **Designator Index** items in the Report descriptor.
- A **Physical Descriptor** has the following parts:

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

Designator Value	Description
00	None
01	Hand
02	Eyeball
03	Eyebrow

Designator Value	Description
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
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 between the **Interface** and **Endpoint** descriptors for HID Interfaces. That is, the order shall be:

```
Configuration descriptor
   Interface descriptor (specifying HID Class)
     HID descriptor (associated with above Interface)
        Endpoint descriptor (for HID Interrupt In Endpoint)
        Optional Endpoint descriptor (for HID Interrupt Out Endpoint)
```

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.”

Remarks

The following table defines the **Descriptor Type** (the high byte of *wValue* in the Get_Descriptor request).

Part	Description
Descriptor Type	Bits specifying characteristics of Descriptor Type: 7 Reserved (should always be 0) 6..5 Type 0 = Standard 1 = Class 2 = Vendor 3 = Reserved 4..0 Descriptor See the standard class or vendor Descriptor Types table.

The following defines valid types of **Class** descriptors.

Value	Class Descriptor Types
0x21	HID
0x22	Report
0x23	Physical descriptor
0x24 - 0x2F	Reserved

7.1.1 Get_Descriptor Request

Description

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

Parts

Part	Standard USB Descriptor	HID Class Descriptor
bmRequestType	100 *xxxxx*	10000001
bRequest	GET_DESCRIPTOR (0x06)	GET_DESCRIPTOR (0x06)
wValue	Descriptor Type and Descriptor Index	Descriptor Type and Descriptor Index
wIndex	0 (zero) or Language ID	Interface Number
wLength	Descriptor Length	Descriptor Length
Data	Descriptor	Descriptor

Remarks

- For standard USB descriptors, bits 0-4 of bmRequestType indicate whether the requested descriptor is associated with the device, interface, endpoint, or other.
- 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.
  - If a **HID** class descriptor is being requested then the *wIndex* field indicates the number of the HID Interface. If a standard descriptor is being requested then the *wIndex* field specifies the Language ID for string descriptors, and is reset to zero for other standard descriptors.
  - Requesting **Physical Descriptor** set 0 returns a special descriptor identifying the number of descriptor sets and their sizes.
  - A **Get_Descriptor** request with the **Physical Index** equal to 1 will request the first **Physical Descriptor** set. A device could possibly have alternate uses for its items. These can be enumerated by issuing subsequent **Get_Descriptor** requests while incrementing the **Descriptor Index**. A device will return the last descriptor set to requests with an index 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. Support of this request is optional.

Parts

Part	Standard USB Descriptor	HID Class Descriptor
bmRequestType	00000000	00000001
bRequest	SET_DESCRIPTOR (0x07)	SET_DESCRIPTOR (0x07)
wValue	Descriptor Type (high) and Descriptor Index (low)	Descriptor Type and Descriptor Index
wIndex	0 (zero) or Language ID	Interface
wLength	Descriptor Length	Descriptor Length
Data	Descriptor	Descriptor

7.2 Class-Specific Requests

Description

Class-specific requests allow the host to inquire about the capabilities and state of a device and to set the state of output and feature items. These transactions are done over the **Default** pipe and therefore follow the format of **Default** pipe requests as defined in the USB Specification.

Parts

Part	Offset/Size (Bytes)	Description
bmRequestType	0/1	Bits specifying characteristics of request. Valid values are 10100001 or 00100001 only based on the following description: 7 Data transfer direction 0 = Host to device 1 = Device to host 6..5 Type 1 = Class 4..0 Recipient 1 = Interface
bRequest	1/1	A specific request.
wValue	2/2	Numeric expression specifying word-size field (varies according to request.)
wIndex	4/2	Index or offset specifying word-size field (varies according to request.)
wLength	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
bmRequestType	10100001
bRequest	GET_REPORT
wValue	Report Type and Report ID
wIndex	Interface
wLength	Report Length
Data	Report

Remarks

- The *wValue* field specifies the **Report Type** in the high byte and the **Report ID** in the low byte. Set **Report ID** to 0 (zero) if **Report ID**s are not used. **Report Type** is specified as follows:

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

- 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 In** pipe should be used for recurring **Input** reports. The **Input** report reply has the same format as the reports from **Interrupt** pipe.
- An **Interrupt Out** pipe may optionally be used for low latency **Output** reports. **Output** reports over the **Interrupt Out** pipe have a format that is identical to output reports that are sent over the **Control** pipe, if an **Interrupt Out** endpoint is not declared.

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
bmRequestType	00100001
bRequest	SET_REPORT
wValue	Report Type and Report ID
wIndex	Interface
wLength	Report Length
Data	Report

Remarks

- The meaning of the request fields for the **Set_Report** request is the same as for the **Get_Report** request, however the data direction is reversed and the Report Data is sent from host to device.
- 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.

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
bmRequestType	10100001
bRequest	GET_IDLE
wValue	0 (zero) and Report ID
wIndex	Interface
wLength	1 (one)
Data	Idle rate

Remarks

For the meaning of the request fields, refer to Section 7.2.4: Set_Idle Request.

7.2.4 Set_Idle Request

Description

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

Parts

Part	Description
bmRequestType	00100001
bRequest	SET_IDLE
wValue	Duration and Report ID
wIndex	Interface
wLength	0 (zero)
Data	Not applicable

Remarks

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

Part	Description
Duration	When the upper byte of *wValue* is 0 (zero), the duration is indefinite. The endpoint will inhibit reporting forever, only reporting when a change is detected in the report data. When the upper byte of *wValue* 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. 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.
Report ID	If the lower byte of wValue is zero, then the idle rate applies to all input reports generated by the device. When the lower byte of wValue is non-zero, then the idle rate only applies to the Report ID specified by the value of the lower byte.
Accuracy	This time duration shall have an accuracy of +/-(10% + 2 milliseconds)
Latency	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. If the current period has gone past the newly proscribed time duration, then a report will be generated immediately.

If the interrupt in endpoint is servicing multiple reports, then the **Set_Idle** request may be used to affect only the rate at which 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
bmRequestType	10100001
bRequest	GET_PROTOCOL
wValue	0 (zero)
wIndex	Interface
wLength	1 (one)
Data	0 = Boot Protocol 1 = Report Protocol

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
bmRequestType	00100001
bRequest	SET_PROTOCOL
wValue	0 = Boot Protocol 1 = Report Protocol
wIndex	Interface
wLength	0 (zero)
Data	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

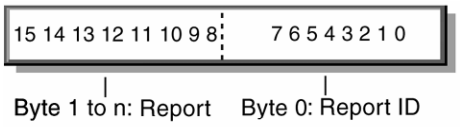
Reports contain data from one or more items. Data transfers are sent from the device to the host through the **Interrupt In** pipe in the form of reports. Reports may also be requested (polled) and sent through the **Control** pipe or sent through an optional **Interrupt Out** pipe. A report contains 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 may 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

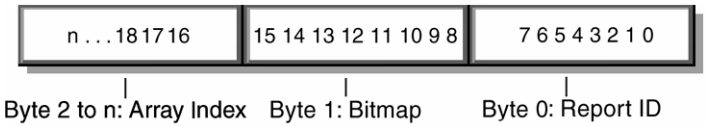
The following example shows the reports generated by a user typing ALT+CTRL+DEL, using a bitmap for the modifiers and a single array for all other keys.

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, each report would be preceded by its unique **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, i.e. **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.
- Only one report is allowed in a single USB transfer.
- 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.
- All reports except the longest which exceed *wMaxPacketSize* for the endpoint must terminate with a short packet. The longest report does not require a short packet terminator.
- Each top level collection must be an application collection and reports may not span more than one top level collection.
- If there are multiple reports in a top level collection then all reports, except the longest, must terminate with a short packet.
- A report is always byte-aligned. If required, reports are padded with bits (0) until the next byte boundary is reached.

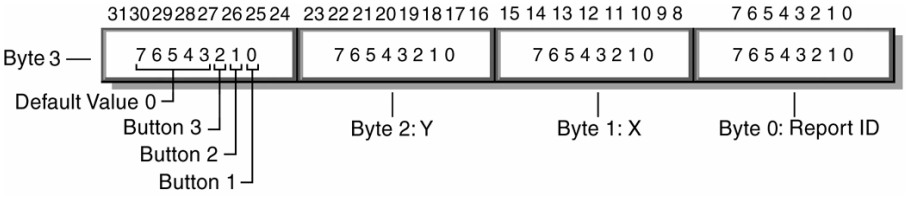
8.5 Report Example

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

```
Usage Page (Generic Desktop),
Usage (Mouse),
Collection (Application),
    Usage (Pointer),
    Collection (Physical),
       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 (3), Report Size (1),
       Usage Page (Button Page),
       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	
`  Report ID (00)`		
`  Input (Variable, Absolute)`	Modifier keys	00
`  Output (Variable, Absolute)`	LEDs	00
`  Input (Array, Absolute)`	Main keys	00
`End Collection`		
`Collection (Application)`	Mouse	
`  Report ID (01)`		
`  Collection (Physical)`	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 Universal Serial Bus HID Usage Tables document for a complete list of Usage Pages and **Usage Tags**, including key codes for keyboards.

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 if an alternative report descriptor is provided. 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),
   Report Size (1),
   Report Count (8),
   Usage Page (Key Codes),
   Usage Minimum (224),
   Usage Maximum (231),
   Logical Minimum (0),
   Logical Maximum (1),
   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
```

The following table represents the keyboard input report (8 bytes).

Byte	Description
0	Modifier keys
1	Reserved
2	Keycode 1
3	Keycode 2
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 keyboard output report (1 byte).

Bit	Description
0	NUM LOCK
1	CAPS LOCK
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 (Physical),
    Report Count (3),
    Report Size (1),
    Usage Page (Buttons),
    Usage Minimum (1),
    Usage Maximum (3),
    Logical Minimum (0),
    Logical Maximum (1),
    Input (Data, Variable, Absolute),
    Report Count (1),
    Report Size (5),
    Input (Constant),
    Report Size (8),
    Report Count (2),
    Usage Page (Generic Desktop),
    Usage (X),
    Usage (Y),
    Logical Minimum (-127),
    Logical Maximum (127),
    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 (optional)

Appendix C: Keyboard Implementation

The following are the 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 support the **Idle** request.
- 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 report a phantom state indexing Usage(ErrorRollOver) in all array fields whenever 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	00000000B	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 (Generic Desktop),
Usage (Joystick),
Collection (Application),
    Usage Page (Generic Desktop),
    Usage (Pointer),
    Collection (Physical),
      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 (Buttons),
      Usage Minimum (Button 1),
      Usage Maximum (Button 2),
      Unit (None),
      Input (Data, Variable, Absolute)
    End Collection,
    Usage Minimum (Button 3),
    Usage Minimum (Button 4),
    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
bLength	0/1	Numeric expression specifying the size of this descriptor.	0x12
bDescriptorType	1/1	Device descriptor type (assigned by USB).	0x01
bcdUSB	2/2	USB HID Specification Release 1.0.	0x100
bDeviceClass	4/1	Class code (assigned by USB). Note that the HID class is defined in the Interface descriptor.	0x00
bDeviceSubClass	5/1	Subclass code (assigned by USB). These codes are qualified by the value of the *bDeviceClass* field.	0x00
bDeviceProtocol	6/1	Protocol code. These codes are qualified by the value of the *bDeviceSubClass* field.	0x00
bMaxPacketSize0	7/1	Maximum packet size for endpoint zero (only 8, 16, 32, or 64 are valid).	0x08
idVendor	8/2	Vendor ID (assigned by USB). For this example we'll use 0xFFFF.	0xFFFF
idProduct	10/2	Product ID (assigned by manufacturer).	0x0001
bcdDevice	12/2	Device release number (assigned by manufacturer).	0x0100
iManufacturer	14/1	Index of String descriptor describing manufacturer.	0x04
iProduct	15/1	Index of string descriptor describing product.	0x0E
iSerialNumber	16/1	Index of String descriptor describing the device's serial number.	0x30
bNumConfigurations	17/1	Number of possible configurations.	0x01

E.2 Configuration Descriptor

Part	Offset/Size (Bytes)	Description	Sample Value
bLength	0/1	Size of this descriptor in bytes.	0x09
bDescriptorType	1/1	Configuration (assigned by USB).	0x02
wTotalLength	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).	0x003B
bNumInterfaces	4/1	Number of interfaces supported by this configuration.	0x02
bConfigurationValue	5/1	Value to use as an argument to Set Configuration to select this configuration.	0x01
iConfiguration	6/1	Index of string descriptor describing this configuration. In this case there is none.	0x00
bmAttributes	7/1	Configuration characteristics 7 Bus Powered 6 Self Powered 5 Remote Wakeup 4..0 Reserved (reset to 0)	10100000B
MaxPower	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
bLength	0/1	Size of this descriptor in bytes.	0x09
bDescriptorType	1/1	Interface descriptor type (assigned by USB).	0x04
bInterfaceNumber	2/1	Number of interface. Zero-based value identifying the index in the array of concurrent interfaces supported by this configuration.	0x00
bAlternateSetting	3/1	Value used to select alternate setting for the interface identified in the prior field.	0x00
bNumEndpoints	4/1	Number of endpoints used by this interface (excluding endpoint zero). If this value is zero, this interface only uses endpoint zero.	0x01
bInterfaceClass	5/1	Class code (HID code assigned by USB).	0x03
bInterfaceSubClass	6/1	Subclass code. 0 No subclass 1 Boot Interface subclass	0x01

Part	Offset/Size (Bytes)	Description	Sample Value
bInterfaceProtocol	7/1	Protocol code. 0 None 1 Keyboard 2 Mouse	0x01
iInterface	8/1	Index of string descriptor describing this interface.	0x00

E.4 HID Descriptor (Keyboard)

Part	Offset/Size (Bytes)	Description	Sample Value
bLength	0/1	Size of this descriptor in bytes.	0x09
bDescriptorType	1/1	HID descriptor type (assigned by USB).	0x21
bcdHID	2/2	HID Class Specification release number in binary-coded decimal—for example, 2.10 is 0x210).	0x101
bCountryCode	4/1	Hardware target country.	0x00
bNumDescriptors	5/1	Number of HID class descriptors to follow.	0x01
bDescriptorType	6/1	Report descriptor type.	0x22
wDescriptorLength	7/2	Total length of Report descriptor.	0x3F

E.5 Endpoint Descriptor (Keyboard)

Part	Offset/Size (Bytes)	Description	Sample Value
bLength	0/1	Size of this descriptor in bytes.	0x07
bDescriptorType	1/1	Endpoint descriptor type (assigned by USB).	0x05
bEndpointAddress	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
bmAttributes	3/1	This field describes the endpoint's attributes when it is configured using the bConfigurationValue. 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
wMaxPacketSize	4/2	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.	0x0008
bInterval	6/1	Interval for polling endpoint for data transfers. Expressed in milliseconds.	0x0A

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

E.8 HID Descriptor (Mouse)

Part	Offset/Size (Bytes)	Description	Sample Value
bLength	0/1	Size of this descriptor in bytes.	0x09
bDescriptorType	1/1	HID descriptor type (assigned by USB).	0x21
bcdHID	2/2	HID Class Specification release number.	0x101
bCountryCode	4/1	Hardware target country.	0x00
bNumDescriptors	5/1	Number of HID class descriptors to follow.	0x01
bDescriptorType	6/1	Report descriptor type.	0x22
wItemLength	7/2	Total length of Report descriptor.	0x32

E.9 Endpoint Descriptor (Mouse)

Part	Offset/Size (Bytes)	Description	Sample Value
bLength	0/1	Size of this descriptor in bytes.	0x07
bDescriptorType	1/1	Endpoint descriptor type (assigned by USB).	0x05
bEndpointAddress	2/1	The address of the endpoint.	10000010B
bmAttributes	3/1	This field describes the endpoint’s attributes.	00000011B
wMaxPacketSize	4/2	Maximum packet size.	0x0008
bInterval	6/1	Interval for polling endpoint for data transfers.	0x0A

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 (Physical),		A1 00
Usage Page (Buttons),		05 09
Usage Minimum (01),		19 01
Usage Maximun (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
bLength	00/01	Length of String descriptor in bytes.	0x04
bDescriptorType	01/01	Descriptor Type = String	0x03
bString	02/02	Array of LangID codes (in this case the 2-byte code for English).	0x0009
bLength	04/01	Length of String descriptor.	0x0A
bDescriptorType	05/01	Descriptor Type = String	0x03
bString	06/08	Manufacturer	ACME
bLength	14/01	Length of String descriptor.	0x22
bDescriptorType	15/01	Descriptor Type = String	0x03
bString	16/32	Product Locator Keyboard	Locator Keyboard
bLength	48/01	Length of String descriptor.	0x0E
bDescriptorType	49/01	Descriptor Type = String	0x03
bString	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 as long as the device responds appropriately to a string request.

Appendix F: Legacy 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 full **HID**-compatible item-based protocols , as well as boot and legacy protocols.

F.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.

F.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.

F.3 Boot Keyboard Requirements

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

- The Boot Keyboard shall report keys in the format described in Appendix B of the **HID** Class specification.
- The Boot Keyboard shall support the **Set_Idle** request.
- The Boot Keyboard shall send data reports when the interrupt in 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 Boot 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 Boot Keyboard.
- The Boot 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 Boot Keyboard shall not maintain CAPS LOCK, NUM LOCK, SCROLL LOCK, COMPOSE, or KANA LED states without explicit **Set_Report (Output)** requests from the system.
- The Boot Keyboard shall support all usage codes of a standard 84-key keyboard. (See: Appendix A.3)
- The Boot Keyboard shall support the **Set_Protocol** request.
- The Boot Keyboard shall, upon reset, return to the non- boot protocol which is described in its **Report** descriptor. That is, the **Report** descriptor for a Boot Keyboard does not necessarily match the boot protocol. The **Report** descriptor for a Boot 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 Boot
   Keyboard)
       HID descriptor (associated with this Interface)
          Endpoint descriptor (HID Interrupt In Endpoint)
               (other Interface, Endpoint, and Vendor Specific
               descriptors if required)
```

F.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 Lock, Num Lock, 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 keyboard is specific to the system and cannot be moved to a generic platform.

F.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 In 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 boot 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 Boot Keyboard case, the keycode table has been written specifically so that the **Usage** is equal to the Logical Index which is reported.

Note: The keypad example below needs to be fixed before the 1.0 document can be finalized.

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

```
Usage Page (Generic Desktop),
Usage (Keyboard),
Report Count (0),
Collection (Application),
  Usage Page(Key Codes),
  Usage(0),                ; key null
  Usage Minimum(53h),
  Usage Maximum(63h),
  Logical Minimum (0),
  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 Num Lock 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 both to be 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 G: HID Request Support Requirements

The following table enumerates the requests that need to be supported by various types of HID class devices.

Device type	Get Report	Set Report[1]	Get Idle	Set Idle	Get Protocol	Set Protocol
Boot Mouse	Required	Optional	Optional	Optional	Required	Required
Non-Boot Mouse	Required	Optional	Optional	Optional	Optional	Optional
Boot Keyboard	Required	Optional	Required	Required	Required	Required
Non-Boot Keyboard	Required	Optional	Required	Required	Optional	Optional
Other Device	Required	Optional	Optional	Optional	Optional	Optional

[1] If a device declares an Output report then support for SetReport(Output) request is required. If an Ouput report is defined, declaration of an Interrupt Out endpoint is optional, however operating systems that do not support HID Interrupt Out endpoints will route all Output reports through the control endpoint using a SetReport(Output) 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.

Boot Device
A device which can be used by host system firmware to assist in system configuration prior to the loading of operating system software. A non-boot device does not need to be functional until the operating system has loaded.

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 an example of a source of data.

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

Data phase
Part of a device’s response to a request.

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

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
Standard USB descriptor describing the type and capabilities of a USB communication channel, or pipe.

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.

Idle rate
The frequency at which a device reports data when no new events have occurred. Most devices only report new events and therefore default to an idle rate of infinity. Keyboards may use the idle rate for auto repeating keys.

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

Interrupt Out pipe
The pipe used to transfer low latency data from the host to the device.

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

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

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 In** pipe is used for stream-type data from the device and an optional **Interrupt Out** pipe may be used for low latency data to the device. 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.

Protocol
A report structure other than the structure defined by the report descriptor. Protocols are used by keyboards and mice to insure BIOS support.

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.

Unknown Usage
Unknown usages can be standard HID usages that an application predates or vendor defined usages not recognized by a generic application.

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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