USB Descriptors

All USB devices have a hierarchy of descriptors which describe to the host information such as what the device is, who makes it, what version of USB it supports, how many ways it can be configured, the number of endpoints and their types etc

The more common USB descriptors are

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

USB devices can only have one device descriptor. The device descriptor includes information such as what USB revision the device complies to, the Product and Vendor IDs used to load the appropriate drivers and the number of possible configurations the device can have. The number of configurations indicate how many configuration descriptors branches are to follow.

The configuration descriptor specifies values such as the amount of power this particular configuration uses, if the device is self or bus powered and the number of interfaces it has. When a device is enumerated, the host reads the device descriptors and can make a decision of which configuration to enable. It can only enable one configuration at a time.

For example, It is possible to have a high power bus powered configuration and a self powered configuration. If the device is plugged into a host with a mains power supply, the device driver may choose to enable the high power bus powered configuration enabling the device to be powered without a connection to the mains, yet if it is connected to a laptop or personal organiser it could enable the 2nd configuration (self powered) requiring the user to plug your device into the power point.

The configuration settings are not limited to power differences. Each configuration could be powered in the same way and draw the same current, yet have different interface or endpoint combinations. However it should be noted that changing the configuration requires all activity on each endpoint to stop. While USB offers this flexibility, very few devices have more than 1 configuration.

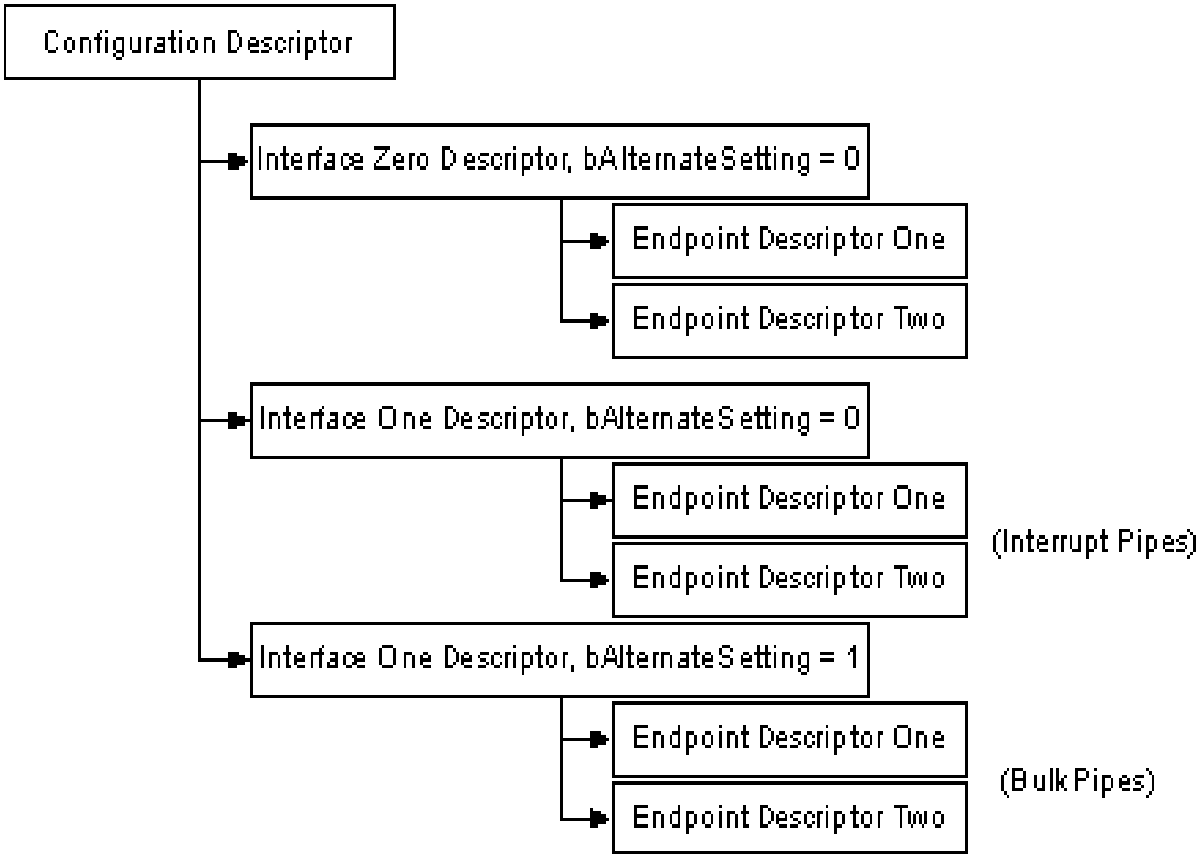
The interface descriptor could be seen as a header or grouping of the endpoints into a functional group performing a single feature of the device. For example you could have a multi-function fax/scanner/printer device. Interface descriptor one could describe the endpoints of the fax function, Interface descriptor two the scanner function and Interface descriptor three the printer function. Unlike the configuration descriptor, there is no limitation as to having only one interface enabled at a time. A device could have 1 or many

interface descriptors enabled at once.

Interface descriptors have a **bInterfaceNumber** field specifying the Interface number and a **bAlternateSetting** which allows an interface to change settings on the fly. For example we could have a device with two interfaces, interface one and interface two. Interface one has **bInterfaceNumber** set to zero indicating it is the first interface descriptor and a **bAlternativeSetting** of zero.

Interface two would have a **bInterfaceNumber** set to one indicating it is the second interface and a **bAlternativeSetting** of zero (default). We could then throw in another descriptor, also with a **bInterfaceNumber** set to one indicating it is the second interface, but this time setting the **bAlternativeSetting** to one, indicating this interface descriptor can be an alternative setting to that of the other interface descriptor two.

When this configuration is enabled, the first two interface descriptors with **bAlternativeSettings** equal to zero is used. However during operation the host can send a SetInterface request directed to that of Interface one with a alternative setting of one to enable the other interface descriptor.



This gives an advantage over having two configurations, in that we can be transmitting data over interface zero while we change the endpoint settings associated with interface one without effecting interface zero.

Each endpoint descriptor is used to specify the type of transfer, direction, polling interval and maximum packet size for each endpoint. Endpoint zero, the default control endpoint is always assumed to be a control endpoint and as such never has a descriptor.

Composition of USB Descriptors

All descriptors are made up of a common format. The first byte specifies the length of the descriptor, while the second byte indicates the descriptor type. If the length of a descriptor is smaller than what the specification defines, then the host shall ignore it. However if the size is greater than expected the host will ignore the extra bytes and start looking for the next descriptor at the end of actual length returned.

Offset	Field	Size	Value	Description
0	bLength	1	Number	Size of Descriptor in Bytes
1	bDescriptionType	1	Constant	DescriptorType
2	...	n		Start of parameters for descriptor

Device Descriptors

The device descriptor of a USB device represents the entire device. As a result a USB device can only have one device descriptor. It specifies some basic, yet important information about the device such as the supported USB version, maximum packet size, vendor and product IDs and the number of possible configurations the device can have. The format of the device descriptor is shown below.

Offset	Field	Size	Value	Description
0	bLength	1	Number	Size of the Descriptor in Bytes (18 bytes)
1	bDescriptorType	1	Constant	Device Descriptor (0x01)
2	bcdUSB	2	BCD	USB Specification Number which device complies too.
4	bDeviceClass	1	Class	Class Code (Assigned by USB Org) If equal to Zero, each interface specifies it’s own class code If equal to 0xFF, the class code is vendor specified. Otherwise field is valid Class Code.

5	bDeviceSubClass	1	SubClass	Subclass Code (Assigned by USB Org)
6	bDeviceProtocol	1	Protocol	Protocol Code (Assigned by USB Org)
7	bMaxPacketSize	1	Number	Maximum Packet Size for Zero Endpoint. Valid Sizes are 8, 16, 32, 64
8	idVendor	2	ID	Vendor ID (Assigned by USB Org)
10	idProduct	2	ID	Product ID (Assigned by Manufacturer)
12	bcdDevice	2	BCD	Device Release Number
14	iManufacturer	1	Index	Index of Manufacturer String Descriptor
15	iProduct	1	Index	Index of Product String Descriptor
16	iSerialNumber	1	Index	Index of Serial Number String Descriptor
17	bNumConfigurations	1	Integer	Number of Possible Configurations

- *The **bcdUSB** field reports the highest version of USB the device supports. The value is in binary coded decimal with a format of 0xJJMN where JJ is the major version number, M is the minor version number and N is the sub minor version number. e.g. USB 2.0 is reported as 0x0200, USB 1.1 as 0x0110 and USB 1.0 as 0x0100.*
- *The **bDeviceClass, bDeviceSubClass** and **bDeviceProtocol** are used by the operating system to find a class driver for your device. Typically only the bDeviceClass is set at the device level. Most class specifications choose to identify itself at the interface level and as a result set the bDeviceClass as 0x00. This allows for the one device to support multiple classes.*
- *The **bMaxPacketSize** field reports the maximum packet size for endpoint zero. All devices must support endpoint zero.*
- *The **idVendor** and **idProduct** are used by the operating system to find a driver for your device. The Vendor ID is assigned by the USB-IF.*
- *The **bcdDevice** has the same format than the bcdUSB and is used to provide a device version number. This value is assigned by the developer.*
- *Three string descriptors exist to provide details of the manufacturer, product and serial number. There is no requirement to have string descriptors. If no string*

descriptor is present, a index of zero should be used.

- ***bNumConfigurations** defines the number of configurations the device supports at its current speed.*

Configuration Descriptors

A USB device can have several different configurations although the majority of devices are simple and only have one. The configuration descriptor specifies how the device is powered, what the maximum power consumption is, the number of interfaces it has. Therefore it is possible to have two configurations, one for when the device is bus powered and another when it is mains powered. As this is a "header" to the Interface descriptors, its also feasible to have one configuration using a different transfer mode to that of another configuration.

Once all the configurations have been examined by the host, the host will send a SetConfiguration command with a non zero value which matches the bConfigurationValue of one of the configurations. This is used to select the desired configuration.

Offset	Field	Size	Value	Description
0	bLength	1	Number	Size of Descriptor in Bytes
1	bDescriptorType	1	Constant	Configuration Descriptor (0x02)
2	wTotalLength	2	Number	Total length in bytes of data returned
4	bNumInterfaces	1	Number	Number of Interfaces
5	bConfigurationValue	1	Number	Value to use as an argument to select this configuration
6	iConfiguration	1	Index	Index of String Descriptor describing this configuration
7	bmAttributes	1	Bitmap	D7 Reserved, set to 1. (USB 1.0 Bus Powered) D6 Self Powered D5 Remote Wakeup D4..0 Reserved, set to 0.
8	bMaxPower	1	mA	Maximum Power Consumption in 2mA

units

- *When the configuration descriptor is read, it returns the entire configuration hierarchy which includes all related interface and endpoint descriptors. The* ***wTotalLength*** *field reflects the number of bytes in the hierarchy.*

- ***bNumInterfaces*** *specifies the number of interfaces present for this configuration.*
- ***bConfigurationValue*** *is used by the SetConfiguration request to select this configuration.*
- ***iConfiguration*** *is a index to a string descriptor describing the configuration in human readable form.*
- ***bmAttributes*** *specify power parameters for the configuration. If a device is self powered, it sets D6. Bit D7 was used in USB 1.0 to indicate a bus powered device, but this is now done by bMaxPower. If a device uses any power from the bus, whether it be as a bus powered device or as a self powered device, it must report its power consumption in bMaxPower. Devices can also support remote wakeup which allows the device to wake up the host when the host is in suspend.*
- ***bMaxPower*** *defines the maximum power the device will drain from the bus. This is in 2mA units, thus a maximum of approximately 500mA can be specified. The specification allows a high powered bus powered device to drain no more than 500mA from Vbus. If a device loses external power, then it must not drain more than indicated in bMaxPower. It should fail any operation it cannot perform without external power.*

Interface Descriptors

The interface descriptor could be seen as a header or grouping of the endpoints into a functional group performing a single feature of the device. The interface descriptor conforms to the following format,

Offset	Field	Size	Value	Description
0	bLength	1	Number	Size of Descriptor in Bytes (9 Bytes)
1	bDescriptorType	1	Constant	Interface Descriptor (0x04)
2	bInterfaceNumber	1	Number	Number of Interface

3	bAlternateSetting	1	Number	Value used to select alternative setting
4	bNumEndpoints	1	Number	Number of Endpoints used for this interface
5	bInterfaceClass	1	Class	Class Code (Assigned by USB Org)
6	bInterfaceSubClass	1	SubClass	Subclass Code (Assigned by USB Org)
7	bInterfaceProtocol	1	Protocol	Protocol Code (Assigned by USB Org)
8	iInterface	1	Index	Index of String Descriptor Describing this interface

- ***bInterfaceNumber*** *indicates the index of the interface descriptor. This should be zero based, and incremented once for each new interface descriptor.*
- ***bAlternativeSetting*** *can be used to specify alternative interfaces. These alternative interfaces can be selected with the Set Interface request.*
- ***bNumEndpoints*** *indicates the number of endpoints used by the interface. This value should exclude endpoint zero and is used to indicate the number of endpoint descriptors to follow.*
- ***bInterfaceClass, bInterfaceSubClass*** *and* ***bInterfaceProtocol*** *can be used to specify supported classes (e.g. HID, communications, mass storage etc.) This allows many devices to use class drivers preventing the need to write specific drivers for your device.*
- ***iInterface*** *allows for a string description of the interface.*

Endpoint Descriptors

Endpoint descriptors are used to describe endpoints other than endpoint zero. Endpoint zero is always assumed to be a control endpoint and is configured before any descriptors are even requested. The host will use the information returned from these descriptors to determine the bandwidth requirements of the bus.

Offset	Field	Size	Value	Description
0	bLength	1	Number	Size of Descriptor in Bytes (7 bytes)
1	bDescriptorType	1	Constant	Endpoint Descriptor (0x05)

2	bEndpointAddress	1	Endpoint	Endpoint Address Bits 0..3b Endpoint Number. Bits 4..6b Reserved. Set to Zero Bits 7 Direction 0 = Out, 1 = In (Ignored for Control Endpoints)
3	bmAttributes	1	Bitmap	Bits 0..1 Transfer Type 00 = Control 01 = Isochronous 10 = Bulk 11 = Interrupt Bits 2..7 are reserved. If Isochronous endpoint, Bits 3..2 = Synchronisation Type (Iso Mode) 00 = No Synchonisation 01 = Asynchronous 10 = Adaptive 11 = Synchronous Bits 5..4 = Usage Type (Iso Mode) 00 = Data Endpoint 01 = Feedback Endpoint 10 = Explicit Feedback Data Endpoint 11 = Reserved
4	wMaxPacketSize	2	Number	Maximum Packet Size this endpoint is capable of sending or receiving
6	bInterval	1	Number	Interval for polling endpoint data transfers. Value in frame counts. Ignored for Bulk & Control Endpoints. Isochronous must equal 1 and field may range from 1 to 255 for interrupt endpoints.

- ***bEndpointAddress*** *indicates what endpoint this descriptor is describing.*
- ***bmAttributes*** *specifies the transfer type. This can either be Control, Interrupt, Isochronous or Bulk Transfers. If an Isochronous endpoint is specified, additional attributes can be selected such as the Synchronisation and usage types.*
- ***wMaxPacketSize*** *indicates the maximum payload size for this endpoint.*
- ***bInterval*** *is used to specify the polling interval of certain transfers. The units are expressed in frames, thus this equates to either 1ms for low/full speed devices and 125us for high speed devices.*

String Descriptors

String descriptors provide human readable information and are optional. If they are not used, any string index fields of descriptors must be set to zero indicating there is no string descriptor available.

The strings are encoded in the Unicode format and products can be made to support multiple languages. String Index 0 should return a list of supported languages. A list of USB Language IDs can be found in Universal Serial Bus Language Identifiers (LANGIDs) version 1.0

Offset	Field	Size	Value	Description
0	bLength	1	Number	Size of Descriptor in Bytes
1	bDescriptorType	1	Constant	String Descriptor (0x03)
2	wLANGID[0]	2	number	Supported Language Code Zero (e.g. 0x0409 English - United States)
4	wLANGID[1]	2	number	Supported Language Code One (e.g. 0x0c09 English - Australian)
n	wLANGID[x]	2	number	Supported Language Code x (e.g. 0x0407 German - Standard)

The above String Descriptor shows the format of String Descriptor Zero. The host should read this descriptor to determine what languages are available. If a language is supported, it can then be referenced by sending the language ID in the wIndex field of a Get Descriptor(String) request.

All subsequent strings take on the format below,

Offset	Field	Size	Value	Description
0	bLength	1	Number	Size of Descriptor in Bytes
1	bDescriptorType	1	Constant	String Descriptor (0x03)
2	bString	n	Unicode	Unicode Encoded String