F2838x USB Library

USER'S GUIDE

Copyright

Texas Instruments
13905 University Boulevard
Sugar Land, TX 77479
http://www.ti.com/c2000

Revision Information

This is version 2.00.00.02 of this document, last updated on Mon May 27 06:54:58 CDT 2019.

Table of Contents

1 Introduction

The Texas Instruments® USB Library is a set of data types and functions for creating USB device, host, or dual mode applications. The contents of the USB library and its associated header files fall into four main groups: general purpose functions, device mode specific functions, host mode specific functions, and mode detection and control functions.

The set of general purpose functions are those that are be used in device, host, and dual mode applications. These include functions to parse USB descriptors and configure features of the USB library. The device specific functions provide the class-independent features required by all USB device applications such as host connection signalling and responding to standard descriptor requests. The USB library also contains a set of modules that handle the class specific requests from the USB host as well as a layer to interact with an application. The USB library provides a set of lower level class-independent host functions required by all USB host applications such as device detection and enumeration, and endpoint management. This lower layer remains mostly invisible to the application, but can be exposed to the application via class specific USB host modules. Like the device mode layer, the host mode class specific modules provide an interface to allow the lower level USB library code to communicate directly over the USB bus and also has a higher level interface that interacts with the application. The USB library also provides functions to configure how the USB controller handles switching between host and device mode operation. The modes and the functions that control them are described in the next section.

1.1 Operating Modes

There are five modes that the USB Library can function in and they are set by application. The run time operating mode of the USB controller is set by the way the USB controller is configured to detect the USB connection to another device. This mode detection can be automatic by using full OTG operation, manual by using dual mode operation, or fixed to either host or device mode. In all cases these modes control how the USB controller interacts with the USB VBUS and USB ID pins.

When an application only needs to run in USB host mode it can choose how the device powers VBUS, the detection of over current, the automatic monitoring of VBUS. These are controlled at initialization time by calls to USBStackModeSet() with on of the eUSBMode∗ values. If the application has no need to monitor VBUS it can choose to use the **eUSBModeForceHost** option. This still provides the ability to control VBUS power and the over current detection but does not allow for monitoring VBUS. When the application does require that the controller be able to monitor VBUS it uses the **eUSBModeHost** setting. This setting also requires that the ID pin be externally tied low as it does not fully disable the OTG mode of operation for mode detection.

If an application only needs to run in device mode there are two options to control how device mode is entered. The USBStackModeSet() function is still used to control the mode but and if the application needs to use the VBUS and ID for other purposes, it can use the **eUSBModeForceDevice** to ignore these pins. The impact of this is that the application is not informed of USB disconnection events because it can no longer monitor VBUS. This is only a problem for self powered applications and can be handled by monitoring VBUS on a separate pin. If the application needs to receive disconnect events it must connect the VBUS pin to the USB connector and leave the ID pin unconnected.

Some application also need to run as either host or device and the USB library provides two methods to handle switching modes on the fly. The first is to use the normal USB OTG signalling to control mode switching which requires both the ID and VBUS pins to be connected to the USB

connector. This is designed to work with a single USB AB connector. Another method of switching operating mode is to allow the application to choose the operating mode of the USB controller manually. This is more useful when the application is using a host and a device connector and can detect when it needs to manually switch the USB operating mode. The APIs and further description is in the dual mode section of this document.

1.2 File Structure and Tools

The following tool chains are supported:

- Texas Instruments Code Composer Studio™

Directory Structure Overview

The following is an overview of the organization of the USB library source code, along with references to where each portion is described in detail.

`ccs`	The directory which contains the CCS project used to build the USB library.
`include`	The directory that contains the headers files for functions and data types which are of general use to device and host applications. Additionally, the sub-directories, host and device, contain the header files relating to operation as a USB host/device.
`source`	The directory that contains the source files for functions and data types which are of general use to device and host applications. The contents of this directory are described in chapter 4.
`source/device/`	This directory contains source code files relating to operation as a USB device. The contents of this directory are described in chapter 2.
`source/host/`	This directory contains source code files relating to operation as a USB host. The contents of this directory are described in chapter 3.

2 Device Functions

2.1 Introduction

This chapter describes the various API layers within the USB library that offer support for applications wishing to present themselves as USB devices. Several programming interfaces are provided ranging from the thinnest layer which merely abstracts the underlying USB controller hardware to high level interfaces offering simple APIs supporting specific devices.

Source Code Overview

Source code and headers for the device specific USB functions can be found in the device directory of the USB library tree, typically `libraries/communications/usb/f2838x/include/device` and `libraries/communications/usb/f2838x/source/device`.

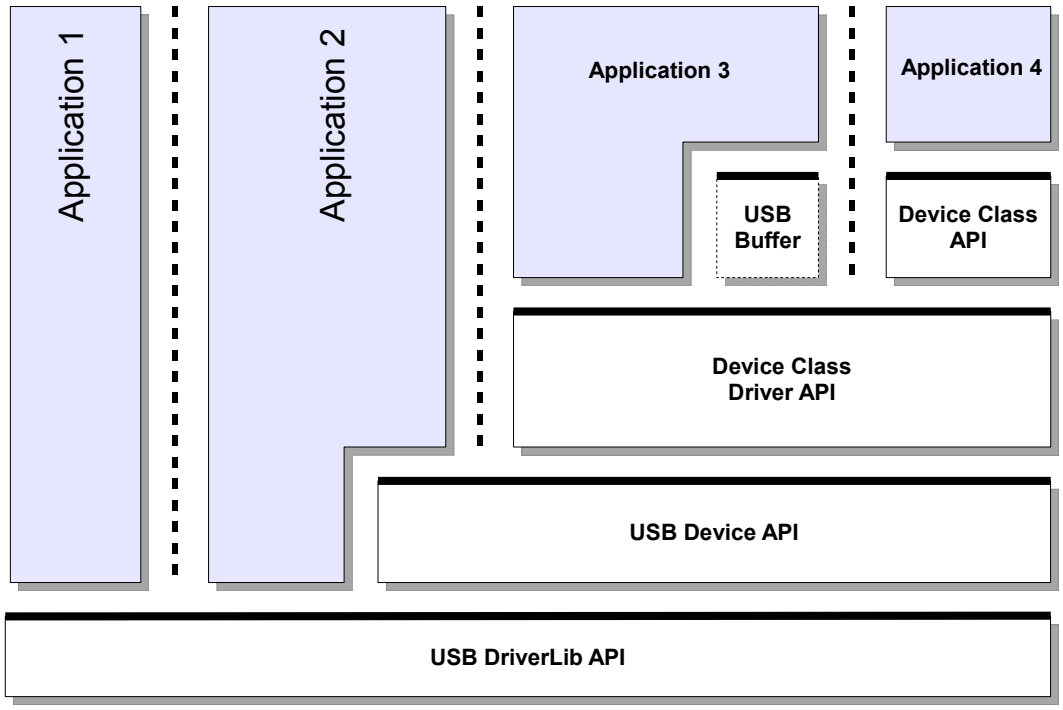
`usbdevice.h`	The header file containing device mode function prototypes and data types offered by the library. This file is the main header file defining the USB Device API.
`usbdbulk.h`	The header file defining the USB generic bulk device class driver API.
`usbdcdc.h`	The header file defining the USB Communication Device Class (CDC) device class driver API.
`usbdhid.h`	The header file defining the USB Human Interface Device (HID) device class driver API.

`usbdhidkeyb.h`	The header file defining the USB HID keyboard device class API.
`usbdhidmouse.h`	The header file defining the USB HID keyboard device class API.
`usbdenum.c`	The source code for the USB device enumeration functions offered by the library.
`usbdhandler.c`	The source code for the USB device interrupt handler.
`usbdconfig.c`	The source code for the USB device configuration functions.
`usbdcdesc.c`	The source code for functions used to parse configuration descriptors defined in terms of an array of sections (as used with the USB Device API).
`usbdbulk.c`	The source code for the USB generic bulk device class driver.
`usbdcdc.c`	The source code for the USB Communication Device Class (CDC) device class driver.
`usbdhid.c`	The source code for the USB Human Interface Device (HID) device class driver.
`usbdhidkeyb.c`	The source code for the USB HID keyboard device class.
`usbdhidmouse.c`	The source code for the USB HID keyboard device class.
`usbdaudio.h`	The header file defining the USB audio device class driver.
`usbdaudio.c`	The source code for the USB audio device class functions offered by the library.
`usbdcomp.c`	The source code for the USB composite device class functions offered by the library.
`usbdcomp.h`	The source code for the USB composite device class driver functions offered by the library.
`usbddfu_rt.c`	The source code for the USB runtime DFU class functions offered by the library.
`usbddfu_rt.h`	The source code for the runtime DFU class devices functions offered by the library.
`usbdevicepriv.h`	The private header file containing definitions shared between various source files in the device directory. Applications must not include this header.

2.2 API choices for USB devices

The USB library contains four API layers relevant to the development of USB device applications. Moving down the stack, each API layer offers greater flexibility to an application but this is balanced by the greater effort required to use the lower layers. The available programming interfaces, starting at the highest level and working downwards, are:

- Device Class APIs
- Device Class Driver APIs
- The USB Device API
- The USB DriverLib API



In the above diagram, bold horizontal lines represent APIs that are available for application use. Four possible applications are shown, each using a different programming interface to implement their USB functionality. The following sections provide an overview of the features and limitations of each layer and indicate the kinds of application which may choose to use that layer.

2.2.1 USB DriverLib API

The lowest layer in the USB device stack is the USB driver which can be found within the Driver Library (DriverLib) with source code in `usb.c` and header file `usb.h`. "Application 1" in the previous diagram offers device functionality by writing directly to this API.

Due to the fact that this API is a very thin layer above the USB controller's hardware registers and, hence, does not offer any higher level USB transaction support (such as endpoint zero transaction processing, standard descriptor and request processing, etc.), applications would not typically use this API as the only way to access USB functionality. This driver would, however, be a suitable interface to use if developing, for example, a third-party USB stack.

2.2.2 USB Device API

The USB Device API offers a group of functions specifically intended to allow development of fully-featured USB device applications with as much of the class-independent code as possible contained in the USB Library. The API supports device enumeration via standard requests from the host and handles the endpoint zero state machine on behalf of the application.

An application using this interface provides the descriptors that it wishes to publish to the host during initialization and these provide the information that the USB Device API requires to configure the hardware. Asynchronous events relating to the USB device are notified to the application by means of a collection of callback functions also provided to the USB Device API on initialization.

This API is used in the development of USB device class drivers and can also be used directly by applications which want to provide USB functionality not supported by an existing class driver. Examples of such devices would be those requiring complex alternate interface settings.

The USB Device API can be thought of as a set of high level device extensions to the USB DriverLib API rather than a wrapper over it. When developing to the USB Device API, some calls to the underlying USB DriverLib API are still necessary.

The header file for the USB Device API is `device/usbdevice.h`.

2.2.3 USB Device Class Driver APIs

Device Class Drivers offer high level USB function to applications wishing to offer particular USB features without having to deal with most of the USB transaction handling and connection management that would otherwise be required. These drivers provide high level APIs for several commonly-used USB device classes with the following features.

- Extremely easy to use. Device setup involves creating a set of static data structures and calling a single initialization API.
- Configurable VID/PID, power parameters and string table to allow easy customization of the device without the need to modify any library code.
- Consistent interfaces. All device class drivers use similar APIs making it very straightforward to move between them.
- Minimal application overhead. The vast majority of USB handling is performed within the class driver and lower layers leaving the application to deal only with reading and writing data.
- May be used with optional USB buffer objects to further simplify data transmission and reception. Using USB buffers, interaction with the device class driver can become as simple as a read/write API with no state machine required to ensure that data is transmitted or received at the correct time.
- Device Class Driver APIs completely wrap the underlying USB Device and USB Driver APIs so only a single API interface is used by the application.

Balancing these advantages, application developers should note the following restrictions that apply when using the Device Class Driver APIs.

- No calls may be made to any other USB layer while the device class driver API is in use.
- Alternate configurations are not supported by the supplied device class drivers.

Device class drivers are currently provided to allow creation of a generic bulk device, a Communication Device Class (virtual serial port) device and a Human Interface Device class device (mouse, keyboard, etc.). A special class driver for composite devices is also included. This acts as a wrapper allowing multiple device class drivers to be used in a single device. Detailed information on each of these classes can be found later in this document.

2.2.4 USB Device Class APIs

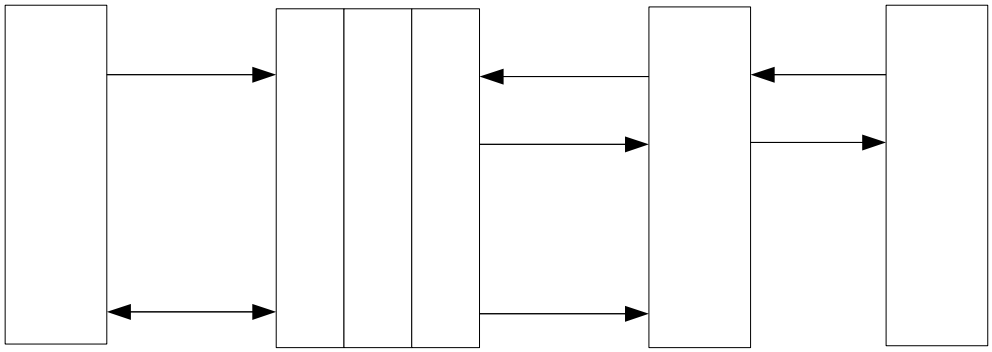
In some cases, a standard device class may offer the possibility of creating a great number of different and varied devices using the same class and in these cases an additional API layer can be provided to further specialize the device operation and simplify the interface to the application.

The Human Interface Device (HID) class is one such class. It is used to support a wide variety of devices including keyboards and mice but the interface is specified in such a way that it could be used for a huge number of vendor-specific devices offering data gathering capability. As a result, the HID device class driver is extremely general to allow support for as wide a range of devices as possible. To simplify the use of the interface, specific APIs are provided to support BIOS-compatible keyboard and mouse operation. Using the mouse class API instead of the base HID class driver API, an application can make itself visible to the USB host as a mouse using an extremely simple interface consisting of an initialization call and a call to inform the host of mouse movement or button presses. Similarly, using the keyboard device class API, the application can use a single API to send key make and break information to the host without having to be aware of the underlying HID structures and USB protocols.

Example applications `usb_ex2_dev_mouse` and `usb_ex3_dev_keyboard` on the C28x side and `usb_ex2_device_mouse_cm` and `usb_ex3_device_keyboard_cm` on the CM make use of the HID mouse and keyboard device class APIs respectively.

2.3 Audio Device Class Driver

The USB audio device class provides a playback interface which allows an application to act as a generic USB audio device to any host operating systems that natively supports USB audio devices. Most operating systems provide native support for generic audio class devices which means that no operating system specific drivers are required. The USB audio device class provides a single 16 bit stereo playback interface at 48kHz sample rate and also provides volume and mute controls.



2.3.1 Handling Audio Playback

The audio playback path is handled by the application passing buffers to be filled to the USB audio class and receiving them back with audio data from the USB host controller. The USB audio class only holds one buffer at a time and will return it to the application when it is full. Because the USB audio class only holds one buffer, it is important to pass in a new buffer to the USB audio class as soon as possible once a buffer is returned to the application to prevent underflow from the USB host controller. Since most audio playback methods uses at least two buffers, one that is playing and one that is being filled, the single buffer in the USB audio class allows for minimal buffering and eliminates copying of data between buffers. When the application has an audio buffer that needs to be filled it passes it to the USB audio class using the USBAudioBufferOut() function. The USB audio class returns the buffer to the application via the audio message handler that the application provided in the pfnHandler member of the tUSBDAudioDevice structure. As soon as the audio device is active the application can provide a buffer to the USB audio class with a call to USBAudioBufferOut(). This call will only fail if the USB audio class already has a buffer, at this point the application must wait for a previous buffer to be returned with a USBD_AUDIO_EVENT_DATAOUT message. Once the USBD_AUDIO_EVENT_DATAOUT message is received, the buffer has been filled and can be played. The buffer provided may not be completely full so the application should only play the portion of the buffer indicated by the message. To prevent underflow the application should always be sure that the audio device class has an empty buffer to fill as soon as a filled buffer is returned. The USB audio class does not provide a way to stop playing audio because typically when the USB host controller stops playing audio the host will simply stop providing data to the USB audio device and playback will stop. This will not result in any notification to the application other than USBD_AUDIO_EVENT_DATAOUT messages will stop being received. If the application needs to stop receiving data, it can simply stop providing buffers to the USB audio class and the audio class will ignore any incoming data from the USB host controller.

2.3.2 Handling Audio Recording

The audio record path is handled by the application receiving messages from the USB audio class that provides a buffer to fill with audio data. The application then provides the buffer back to the USB audio class filled with the requested amount of data for sending back to the USB host controller. The application will receive a USBD_AUDIO_EVENT_DATAIN message requesting that a buffer be filled with a given amount of data. This buffer should then be filled by the application with the requested amount of data and returned to the USB audio class with a call to USBAudioBufferIn(). This buffer will then be set to be transferred back to the USB host controller as recorded audio. In order to reduce the probability of under run to the USB host controller, the the application should be capable of handling two outstanding buffer requests at a time. If the requested buffer cannot be filled with data for any reason, then the application should call USBAudioBufferIn() with the buffer pointer provided by the USBD_AUDIO_EVENT_DATAIN message and set the number of bytes in the buffer to zero. This idicates that the application failed to handle the buffer and no data was available at this time. Like the play back path the USB audio class provides no method to stop receiving messages. If the the application needs to stall the audio, it can simply hold on to the buffers it receives until it can fill them. This will result in under flow in the USB audio class which will be handled by the USB host operating system.

2.3.3 Handling Other Audio Messages

The USB audio class also provides a few other notification messages to the application. These are the USBD_AUDIO_EVENT_VOLUME and USBD_AUDIO_EVENT_MUTE messages which are both inform the application of volume and mute changes in the playback stream. The USBD_AUDIO_EVENT_VOLUME message returns a value that ranges from 0 - 100 in percentage for the playback volume. The USBD_AUDIO_EVENT_MUTE is either zero indicating that the playback path is not muted or 1 indicating that the playback path is muted. The application should always take care to defer any lenghty processing of messages to its non-callback routines to prevent underflow/overflow conditions from occuring.

2.3.4 Using the Generic Audio Device Class

To add USB Audio data playback capability to your application via the Audio Device Class Driver, take the following steps.

- Add the following header files to the source file(s) which are to support USB C28x and CM:

```
#include "usb.h"
#include "include/usblib.h"
#include "include/device/usbdevice.h"
#include "include/device/usbdaudio.h"
```

- Define the six entry string descriptor table which is used to describe various features of your new device to the host system. The following is the string table taken from the `usb_dev_audio` example application. Edit the actual strings to suit your application and take care to ensure that you also update the length field (the first byte) of each descriptor to correctly reflect the length of the string and descriptor header. The number of string descriptors you include must be (1 + (5 $*$ num languages)) where the number of languages agrees with the list published in string descriptor 0, *g_pLangDescriptor*. The strings for each language

must be grouped together with all the language 1 strings before all the language 2 strings and so on.

```
//*****************************************************************************
//
// The languages supported by this device.
//
//*****************************************************************************
const uint8_t g_pui8LangDescriptor[] =
{
    4,
    USB_DTYPE_STRING,
    USBShort(USB_LANG_EN_US)
};

//*****************************************************************************
//
// The manufacturer string.
//
//*****************************************************************************
const uint8_t g_pui8ManufacturerString[] =
{
    (17 + 1) * 2,
    USB_DTYPE_STRING,
    'T', 0, 'e', 0, 'x', 0, 'a', 0, 's', 0, ' ', 0, 'I', 0, 'n', 0, 's', 0,
    't', 0, 'r', 0, 'u', 0, 'm', 0, 'e', 0, 'n', 0, 't', 0, 's', 0,
};

//*****************************************************************************
//
// The product string.
//
//*****************************************************************************
const uint8_t g_pui8ProductString[] =
{
    (13 + 1) * 2,
    USB_DTYPE_STRING,
    'A', 0, 'u', 0, 'd', 0, 'i', 0, 'o', 0, ' ', 0, 'E', 0, 'x', 0, 'a', 0,
    'm', 0, 'p', 0, 'l', 0, 'e', 0
};

//*****************************************************************************
//
// The serial number string.
//
//*****************************************************************************
const uint8_t g_pui8SerialNumberString[] =
{
    (8 + 1) * 2,
    USB_DTYPE_STRING,
    '1', 0, '2', 0, '3', 0, '4', 0, '5', 0, '6', 0, '7', 0, '8', 0
};
```

```
//*****************************************************************************
//
// The interface description string.
//
//*****************************************************************************
const uint8_t g_pui8HIDInterfaceString[] =
{
    (15 + 1) * 2,
    USB_DTYPE_STRING,
    'A', 0, 'u', 0, 'd', 0, 'i', 0, 'o', 0, ' ', 0, 'I', 0, 'n', 0,
    't', 0, 'e', 0, 'r', 0, 'f', 0, 'a', 0, 'c', 0, 'e', 0
};

//*****************************************************************************
//
// The configuration description string.
//
//*****************************************************************************
const uint8_t g_pui8ConfigString[] =
{
    (20 + 1) * 2,
    USB_DTYPE_STRING,
    'A', 0, 'u', 0, 'd', 0, 'i', 0, 'o', 0, ' ', 0, ' ', 0, 'C', 0,
    'o', 0, 'n', 0, 'f', 0, 'i', 0, 'g', 0, 'u', 0, 'r', 0, 'a', 0,
    't', 0, 'i', 0, 'o', 0, 'n', 0
};

//*****************************************************************************
//
// The descriptor string table.
//
//*****************************************************************************
const uint8_t * const g_ppui8StringDescriptors[] =
{
    g_pui8LangDescriptor,
    g_pui8ManufacturerString,
    g_pui8ProductString,
    g_pui8SerialNumberString,
    g_pui8HIDInterfaceString,
    g_pui8ConfigString
};

#define NUM_STRING_DESCRIPTORS (sizeof(g_ppui8StringDescriptors) /           \
                                sizeof(uint8_t *))
```

- Define a *tUSBDAudioDevice* structure and initialize all fields as required for your application.

```
const tUSBDAudioDevice g_sAudioDevice =
{
    //
    // The Vendor ID you have been assigned by USB-IF.
    //
```

```
USB_VID_YOUR_VENDOR_ID,

//
// The product ID you have assigned for this device.
//
USB_PID_YOUR_PRODUCT_ID,

//
// The vendor string for your device (8 chars).
//
USB_YOUR_VENDOR_STRING,

//
// The product string for your device (16 chars).
//
USB_YOUR_PRODUCT_STRING,

//
// The revision string for your device (4 chars BCD).
//
USB_YOUR_REVISION_STRING,

//
// The power consumption of your device in milliamps.
//
POWER_CONSUMPTION_MA,

//
// The value to be passed to the host in the USB configuration descriptor's
// bmAttributes field.
//
USB_CONF_ATTR_SELF_PWR,

//
// A pointer to your control callback event handler.
//
YourUSBAudioMessageHandler,

//
// A pointer to your string table.
//
g_ppui8StringDescriptors,

//
// The number of entries in your string table.
//
NUM_STRING_DESCRIPTORS,

//
// Maximum volume setting expressed as and 8.8 signed fixed point number.
//
VOLUME_MAX,
```

```
        //
        // Minimum volume setting expressed as and 8.8 signed fixed point number.
        //
        VOLUME_MIN,

        //
        // Minimum volume step expressed as and 8.8 signed fixed point number.
        //
        VOLUME_STEP
    };
```

- From your main initialization function call the audio device class driver initialization function to configure the USB controller and place the device on the bus.

```
    pvDevice = USBDAudioInit(0, &g_sAudioDevice);
```

- Assuming *pvDevice* returned is not NULL, your device is now ready to communicate with a USB host.
- Once the host connects, the audio message handler will be sent the **USB_EVENT_CONNECTED** event.
- Once the host is configured to use the Audio device the audio message handler will be called with a **USBD_AUDIO_EVENT_ACTIVE** event.

2.3.5 Using the Audio Device Class in a Composite Device

When using the audio device class in a composite device, the configuration of the device is very similar to how it is configured as a non-composite device. Follow all of the configuration steps in the previous section with the exception of calling USBDAudioCompositeInit() instead of USBDAudioInit(). This will prepare an instance of the audio device class to be enumerated as part of a composite device. The USBDAudioCompositeInit() function takes the audio device structure and a pointer to a tCompositeEntry value so that it can properly initialize the audio device and the composite entry that will later be passed to the USBDCompositeInit() funtion. The code example below provides an example of how to initialize an audio device to be a part of a composite device.

```
//
// These should be initialized with valid values for each class.
//
extern tUSBDAudioDevice g_sAudioDevice;
void *pvAudioDevice;

//
// The array of composite device entries.
//
tCompositeEntry psCompEntries[2];

//
// Allocate the device data for the top level composite device class.
//
tUSBDCompositeDevice g_sCompDevice =
{
```

```
        //
        // Texas Instruments C-Series VID.
        //
        USB_VID_TI_1CBE,

        //
        // Texas Instruments C-Series PID for composite serial device.
        //
        USB_PID_YOUR_COMPOSITE_PID,

        //
        // This is in 2mA increments so 500mA.
        //
        250,

        //
        // Bus powered device.
        //
        USB_CONF_ATTR_BUS_PWR,

        //
        // Composite event handler.
        //
        EventHandler,

        //
        // The string table.
        //
        g_pui8StringDescriptors,
        NUM_STRING_DESCRIPTORS,

        //
        // The Composite device array.
        //
        2,
        g_psCompEntries
    };

    //
    // The OTHER_SIZES here are the sizes of the descriptor data for other classes
    // that are part of the composite device.
    //
    #define DESCRIPTOR_DATA_SIZE    (COMPOSITE_DAUDIO_SIZE + OTHER_SIZES)
    uint8_t g_pui8DescriptorData[DESCRIPTOR_DATA_SIZE];

    //
    // Initialize the audio device and its composite entry which is entry 0.
    //
    pvAudioDevice = USBDAudioCompositeInit(0, &g_sAudioDevice, &psCompEntries[0]);

    //
    // Initialize other devices to add to the composite device.
```

```
//

...

USBDCompositeInit(0, &g_sCompDevice, DESCRIPTOR_DATA_SIZE,
                  g_pui8DescriptorData);
```

All other API calls to the USB audio device class should use the value returned by USBDAudioCompositeInit() when the APIs call for a pvInstance pointer. Also when using the audio device in a composite device the COMPOSITE_DAUDIO_SIZE value should be added to the size of the g_pui8DescriptorData array as shown in the example above.

2.3.6 Audio Device Class Events

The audio device class driver sends the following events to the application callback functions:

- USBD_AUDIO_EVENT_IDLE - Audio interface is idle.
- USBD_AUDIO_EVENT_ACTIVE - Audio interface is active.
- USBD_AUDIO_EVENT_DATAOUT - Audio playback buffer released.
- USBD_AUDIO_EVENT_DATAIN - Audio record buffer ready.
- USBD_AUDIO_EVENT_VOLUME - Audio playback volume change.
- USBD_AUDIO_EVENT_MUTE - Audio mute change.

2.4 Audio Device Class Driver Definitions

Data Structures

- tUSBDAudioDevice

Defines

- COMPOSITE_DAUDIO_SIZE
- USBD_AUDIO_EVENT_ACTIVE
- USBD_AUDIO_EVENT_DATAOUT
- USBD_AUDIO_EVENT_IDLE
- USBD_AUDIO_EVENT_MUTE
- USBD_AUDIO_EVENT_VOLUME

Functions

- int32_t USBAudioBufferOut (void *pvAudioDevice, void *pvBuffer, uint32_t ui32Size, tUSBAudioBufferCallback pfnCallback)

- void * USBDAudioCompositeInit (uint32_t ui32Index, tUSBDAudioDevice *psAudioDevice, tCompositeEntry *psCompEntry)
- void * USBDAudioInit (uint32_t ui32Index, tUSBDAudioDevice *psAudioDevice)
- void USBDAudioTerm (void *pvAudioDevice)

2.4.1 Detailed Description

The macros and functions defined in this section can be found in header file `device/usbdaudio.h`.

2.4.2 Data Structure Documentation

2.4.2.1 tUSBDAudioDevice

Definition:

```
typedef struct
{
    const uint16_t ui16VID;
    const uint16_t ui16PID;
    const char pcVendor[8];
    const char pcProduct[16];
    const char pcVersion[4];
    const uint16_t ui16MaxPowermA;
    const uint8_t ui8PwrAttributes;
    tUSBCallbackconst pfnCallback;
    const uint8_t *const *ppui8StringDescriptors;
    const uint32_t ui32NumStringDescriptors;
    const int16_t i16VolumeMax;
    const int16_t i16VolumeMin;
    const int16_t i16VolumeStep;
    tAudioInstance sPrivateData;
}
tUSBDAudioDevice
```

Members:

ui16VID The vendor ID that this device is to present in the device descriptor.

ui16PID The product ID that this device is to present in the device descriptor.

pcVendor 8 byte vendor string.

pcProduct 16 byte vendor string.

pcVersion 4 byte vendor string.

ui16MaxPowermA The maximum power consumption of the device, expressed in mA.

ui8PwrAttributes Indicates whether the device is self or bus-powered and whether or not it supports remote wake up. Valid values are USB_CONF_ATTR_SELF_PWR or USB_CONF_ATTR_BUS_PWR, optionally ORed with USB_CONF_ATTR_RWAKE.

pfnCallback A pointer to the callback function which will be called to notify the application of events relating to the operation of the audio device.

ppui8StringDescriptors A pointer to the string descriptor array for this device. This array must contain the following string descriptor pointers in this order. Language descriptor,

Manufacturer name string (language 1), Product name string (language 1), Serial number string (language 1), Audio Interface description string (language 1), Configuration description string (language 1).
If supporting more than 1 language, the descriptor block (except for string descriptor 0) must be repeated for each language defined in the language descriptor.

ui32NumStringDescriptors The number of descriptors provided in the ppStringDescriptors array. This must be 1 + ((5 + (number of strings)) * (number of languages)).

i16VolumeMax The maximum volume expressed as an 8.8 signed value.

i16VolumeMin The minimum volume expressed as an 8.8 signed value.

i16VolumeStep The minimum volume step expressed as an 8.8 signed value.

sPrivateData The private instance data for the audio device.

Description:
The structure used by the application to define operating parameters for the device audio class.

2.4.3 Define Documentation

2.4.3.1 COMPOSITE_DAUDIO_SIZE

Definition:
```
#define COMPOSITE_DAUDIO_SIZE
```

Description:
The size of the memory that should be allocated to create a configuration descriptor for a single instance of the USB Audio Device. This does not include the configuration descriptor which is automatically ignored by the composite device class.

2.4.3.2 USBD_AUDIO_EVENT_ACTIVE

Definition:
```
#define USBD_AUDIO_EVENT_ACTIVE
```

Description:
This USB audio event indicates that the device is connected and is now active.

2.4.3.3 USBD_AUDIO_EVENT_DATAOUT

Definition:
```
#define USBD_AUDIO_EVENT_DATAOUT
```

Description:
This USB audio event indicates that the device is returning a data buffer provided by the USBAudioBufferOut() function back to the application with valid audio data received from the USB host controller. The *pvBuffer* parameter holds the pointer to the buffer with the new audio data and the *ui32Param* value holds the amount of valid data in bytes that are contained in the *pvBuffer* parameter.

2.4.3.4 USBD_AUDIO_EVENT_IDLE

Definition:

```
#define USBD_AUDIO_EVENT_IDLE
```

Description:

This USB audio event indicates that the device is connected but not active.

2.4.3.5 USBD_AUDIO_EVENT_MUTE

Definition:

```
#define USBD_AUDIO_EVENT_MUTE
```

Description:

This USB audio event indicates that a mute request has occurred. The *ui32Param* value will either be a 1 to indicate that the audio is now muted, and a value of 0 indicates that the audio has been unmuted.

2.4.3.6 USBD_AUDIO_EVENT_VOLUME

Definition:

```
#define USBD_AUDIO_EVENT_VOLUME
```

Description:

This USB audio event indicates that a volume change has occurred. The *ui32Param* value contains a signed 8.8 fixed point value that represents the current volume gain/attenuation in decibels(dB). The provided message handler should be prepared to handle negative and positive values with the value 0x8000 indicating maximum attenuation. The *pvBuffer* parameter should be ignored.

2.4.4 Function Documentation

2.4.4.1 USBAudioBufferOut

This function is used to supply buffers to the audio class to be filled from the USB host device.

Prototype:

```
int32_t
USBAudioBufferOut(void *pvAudioDevice,
                  void *pvBuffer,
                  uint32_t ui32Size,
                  tUSBAudioBufferCallback pfnCallback)
```

Parameters:

pvAudioDevice is the pointer to the device instance structure as returned by USBDAudioInit() or USBDAudioCompositeInit().

pvBuffer is a pointer to the buffer to fill with audio data.

ui32Size is the size in bytes of the buffer pointed to by the *pvBuffer* parameter.

pfnCallback is a callback that will provide notification when this buffer has valid data.

Description:

This function fills the buffer pointed to by the *pvBuffer* parameter with at most *ui32Size* one packet of data from the host controller. The *ui32Size* has a minimum value of **ISOC_OUT_EP_MAX_SIZE** since each USB packet can be at most **ISOC_OUT_EP_MAX_SIZE** bytes in size. Since the audio data may not be received in amounts that evenly fit in the buffer provided, the buffer may not be completely filled. The *pfnCallback* function will provide the amount of valid data that was actually stored in the buffer provided. The function will return zero if the buffer could be scheduled to be filled, otherwise the function will return a non-zero value if there was some reason that the buffer could not be added.

Returns:

Returns 0 to indicate success any other value indicates that the buffer will not be filled.

2.4.4.2 USBDAudioCompositeInit

This function should be called once for the audio class device to initialized basic operation and prepare for enumeration.

Prototype:

```
void *
USBDAudioCompositeInit(uint32_t ui32Index,
                       tUSBDAudioDevice *psAudioDevice,
                       tCompositeEntry *psCompEntry)
```

Parameters:

ui32Index is the index of the USB controller to initialize for audio class device operation.

psAudioDevice points to a structure containing parameters customizing the operation of the audio device.

psCompEntry is the composite device entry to initialize when creating a composite device.

Description:

In order for an application to initialize the USB audio device class, it must first call this function with the a valid audio device class structure in the *psAudioDevice* parameter. This allows this function to initialize the USB controller and device code to be prepared to enumerate and function as a USB audio device. When this audio device is part of a composite device, then the *psCompEntry* should point to the composite device entry to initialize. This is part of the array that is passed to the USBDCompositeInit() function.

This function returns a void pointer that must be passed in to all other APIs used by the audio class.

See the documentation on the tUSBDAudioDevice structure for more information on how to properly fill the structure members.

Returns:

Returns zero on failure or a non-zero instance value that should be used with the remaining USB audio APIs.

2.4.4.3 USBDAudioInit

This function should be called once for the audio class device to initialized basic operation and prepare for enumeration.

Prototype:

```
void *
USBDAudioInit(uint32_t ui32Index,
              tUSBDAudioDevice *psAudioDevice)
```

Parameters:

ui32Index is the index of the USB controller to initialize for audio class device operation.

psAudioDevice points to a structure containing parameters customizing the operation of the audio device.

Description:

In order for an application to initialize the USB audio device class, it must first call this function with the a valid audio device class structure in the *psAudioDevice* parameter. This allows this function to initialize the USB controller and device code to be prepared to enumerate and function as a USB audio device.

This function returns a void pointer that must be passed in to all other APIs used by the audio class.

See the documentation on the tUSBDAudioDevice structure for more information on how to properly fill the structure members.

Returns:

Returns 0 on failure or a non-zero void pointer on success.

2.4.4.4 USBDAudioTerm

Shuts down the audio device.

Prototype:

```
void
USBDAudioTerm(void *pvAudioDevice)
```

Parameters:

pvAudioDevice is the pointer to the device instance structure as returned by USBDAudioInit().

Description:

This function terminates audio interface for the instance supplied. This function should not be called if the audio device is part of a composite device and instead the USBDCompositeTerm() function should be called for the full composite device. Following this call, the *pvAudioDevice* instance should not me used in any other calls.

Returns:

None.

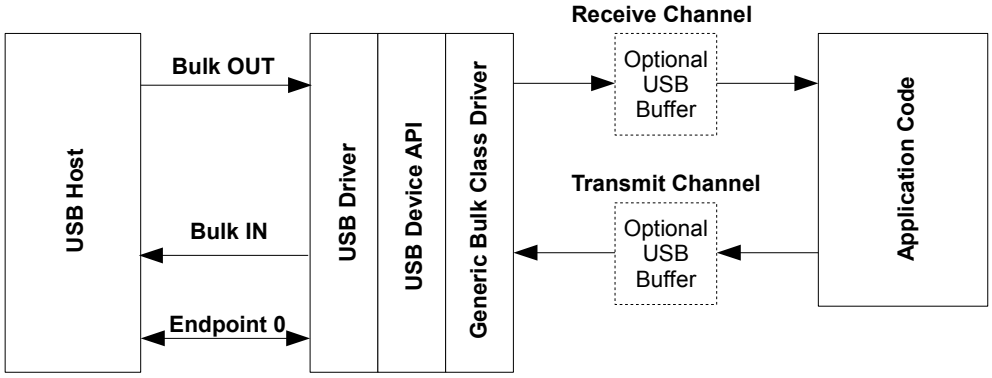
2.5 Bulk Device Class Driver

Although not offering support for a particular standard device class, the generic bulk device class driver offers a very simple method for an application to set up USB communication with a paired application running on the USB host system. The class driver offers a single bulk receive channel and a single bulk transmit channel and, when coupled with USB buffers on each channel, provides a straightforward read/write interface to the application.

The device supports a single interface containing bulk IN and bulk OUT endpoints. The configuration and interface descriptors published by the device contain vendor specific class identifiers so an application on the host will have to communicate with the device using either a custom driver or a subsystem such as WinUSB or libusb-win32 on Windows to allow the device to be accessed. An example of this is provided on the C28x side `usb_ex4_dev_bulk` application and on the CM side as `usb_ex4_device_bulk_cm` application .

This class driver is particularly useful for applications which intend passing high volumes of data via USB and where host-side application code is being developed in partnership with the device.

USB Generic Bulk Device Model



The C28x `usb_ex4_dev_bulk` example application and CM `usb_ex4_device_bulk_cm` example application makes use of this device class driver.

2.5.1 Bulk Device Class Events

The bulk device class driver sends the following events to the application callback functions:

2.5.1.1 Receive Channel Events

- **USB_EVENT_RX_AVAILABLE**
- **USB_EVENT_ERROR**
- **USB_EVENT_CONNECTED**
- **USB_EVENT_DISCONNECTED**

- **USB_EVENT_SUSPEND**
- **USB_EVENT_RESUME**

Note: The USB_EVENT_DISCONNECTED event will not be reported to the application if the MCU's PB1/USB0VBUS pin is connected to a fixed +5 Volts rather than directly to the VBUS pin on the USB connector or if the USB controller is configured to force device mode.

2.5.1.2 Transmit Channel Events

- **USB_EVENT_TX_COMPLETE**

2.5.2 Using the Generic Bulk Device Class

To add USB bulk data transmit and receive capability to your application via the Generic Bulk Device Class Driver, take the following steps.

- Add the following header files to the source file(s) which are to support USB:

```
#include "usb.h"
#include "include/usblib.h"
#include "include/device/usbdevice.h"
#include "include/device/usbdbulk.h"
```

- Define the 5 entry string table which is used to describe various features of your new device to the host system. The following is the string table taken from the C28x `usb_ex4_dev_bulk` example application and CM `usb_ex4_device_bulk_cm` example application. Edit the actual strings to suit your application and take care to ensure that you also update the length field (the first byte) of each descriptor to correctly reflect the length of the string and descriptor header. The number of strings you include must be 5 * (number of languages listed in string descriptor 0, *g_pLangDescriptor*, and the strings for each language must be grouped together with all the language 1 strings before all the language 2 strings and so on.

```
//*****************************************************************************
//
// The languages supported by this device.
//
//*****************************************************************************
const uint8_t g_pLangDescriptor[] =
{
    4,
    USB_DTYPE_STRING,
    USBShort(USB_LANG_EN_US)
};

//*****************************************************************************
//
// The manufacturer string.
//
//*****************************************************************************
const uint8_t g_pManufacturerString[] =
{
```

```
    (17 + 1) * 2,
    USB_DTYPE_STRING,
    'T', 0, 'e', 0, 'x', 0, 'a', 0, 's', 0, ' ', 0, 'I', 0, 'n', 0, 's', 0,
    't', 0, 'r', 0, 'u', 0, 'm', 0, 'e', 0, 'n', 0, 't', 0, 's', 0,
};

//*****************************************************************************
//
// The product string.
//
//*****************************************************************************
const uint8_t g_pProductString[] =
{
    (19 + 1) * 2,
    USB_DTYPE_STRING,
    'G', 0, 'e', 0, 'n', 0, 'e', 0, 'r', 0, 'i', 0, 'c', 0, ' ', 0, 'B', 0,
    'u', 0, 'l', 0, 'k', 0, ' ', 0, 'D', 0, 'e', 0, 'v', 0, 'i', 0, 'c', 0,
    'e', 0
};

//*****************************************************************************
//
// The serial number string.
//
//*****************************************************************************
const uint8_t g_pSerialNumberString[] =
{
    (8 + 1) * 2,
    USB_DTYPE_STRING,
    '1', 0, '2', 0, '3', 0, '4', 0, '5', 0, '6', 0, '7', 0, '8', 0
};

//*****************************************************************************
//
// The data interface description string.
//
//*****************************************************************************
const uint8_t g_pDataInterfaceString[] =
{
    (19 + 1) * 2,
    USB_DTYPE_STRING,
    'B', 0, 'u', 0, 'l', 0, 'k', 0, ' ', 0, 'D', 0, 'a', 0, 't', 0,
    'a', 0, ' ', 0, 'I', 0, 'n', 0, 't', 0, 'e', 0, 'r', 0, 'f', 0,
    'a', 0, 'c', 0, 'e', 0
};

//*****************************************************************************
//
// The configuration description string.
//
//*****************************************************************************
const uint8_t g_pConfigString[] =
```

```
    {
        (23 + 1) * 2,
        USB_DTYPE_STRING,
        'B', 0, 'u', 0, 'l', 0, 'k', 0, ' ', 0, 'D', 0, 'a', 0, 't', 0,
        'a', 0, ' ', 0, 'C', 0, 'o', 0, 'n', 0, 'f', 0, 'i', 0, 'g', 0,
        'u', 0, 'r', 0, 'a', 0, 't', 0, 'i', 0, 'o', 0, 'n', 0
    };

    //*****************************************************************************
    //
    // The descriptor string table.
    //
    //*****************************************************************************
    const uint8_t * const g_pStringDescriptors[] =
    {
        g_pLangDescriptor,
        g_pManufacturerString,
        g_pProductString,
        g_pSerialNumberString,
        g_pDataInterfaceString,
        g_pConfigString
    };

    #define NUM_STRING_DESCRIPTORS (sizeof(g_pStringDescriptors)                 /
                                    sizeof(uint8_t *))
```

- Define a *tUSBDBulkDevice* structure and initialize all fields as required for your application. The following example illustrates a simple case where no USB buffers are in use. For an example using USB buffers, see the source file `usb_ex4_bulk_structs.c` in the `usb_ex4_dev_bulk` C28x example application and `usb_ex4_dev_bulk.c` in the `usb_ex4_device_bulk_cm` CM example application.

```
const tUSBDBulkDevice g_sBulkDevice =
{
    //
    // The Vendor ID you have been assigned by USB-IF.
    //
    USB_VID_YOUR_VENDOR_ID,

    //
    // The product ID you have assigned for this device.
    //
    USB_PID_YOUR_PRODUCT_ID,

    //
    // The power consumption of your device in milliamps.
    //
    POWER_CONSUMPTION_MA,

    //
    // The value to be passed to the host in the USB configuration descriptor's
    // bmAttributes field.
    //
```

```
    USB_CONF_ATTR_SELF_PWR,

    //
    // A pointer to your receive callback event handler.
    //
    YourUSBReceiveEventCallback,

    //
    // A value that you want passed to the receive callback alongside every
    // event.
    //
    (void *)&g_sYourInstanceData,

    //
    // A pointer to your transmit callback event handler.
    //
    YourUSBTransmitEventCallback,

    //
    // A value that you want passed to the transmit callback alongside every
    // event.
    //
    (void *)&g_sYourInstanceData,

    //
    // A pointer to your string table.
    //
    g_ppui8StringDescriptors,

    //
    // The number of entries in your string table.
    //
    NUM_STRING_DESCRIPTORS
};
```

- Add a receive event handler function, YourUSBReceiveEventCallback in the previous example, to your application taking care to handle all messages which require a particular response. For the generic bulk device class, only the **USB_EVENT_RX_AVAILABLE** MUST be handled by the receive event handler. In response to **USB_EVENT_RX_AVAILABLE**, your handler should check the amount of data received by calling USBDBulkRxPacketAvailable() then read it using a call to USBDBulkPacketRead(). This causes the newly received data to be acknowledged to the host and instructs the host that it may now transmit another packet. If you are unable to read the data immediately, return 0 from the callback handler and you will be called back once again a few milliseconds later. Although no other events must be handled, **USB_EVENT_CONNECTED** and **USB_EVENT_DISCONNECTED** will typically be required since these indicate when a host connects or disconnects and allow the application to flush any buffers or reset state as required. Attempts to send data when the host is disconnected will fail.
- Add a transmit event handler function, YourUSBTransmitEventCallback in the previous example, to your application taking care to handle all messages which require a particular response. For the generic bulk device class, there are no events sent to the transmit callback which MUST be handled but applications will usually want to note **USB_EVENT_TX_COMPLETE** since this

is an interlock message indicating that the previous packet sent has been acknowledged by the host and a new packet can now be sent.

- From your main initialization function call the generic bulk device class driver initialization function to configure the USB controller and place the device on the bus.

```
pvDevice = USBDBulkInit(0, &g_sBulkDevice);
```

- Assuming *pvDevice* returned is not NULL, your device is now ready to communicate with a USB host.
- Once the host connects, your receive event handler will be sent **USB_EVENT_CONNECTED** and the first packet of data may be sent to the host using USBDBulkPacketWrite() with following packets transmitted as soon as **USB_EVENT_TX_COMPLETE** is received.

2.5.3 Using the Bulk Device Class in a Composite Device

When using the bulk device class in a composite device, the configuration of the device is very similar to how it is configured as a non-composite device. Follow all of the configuration steps in the previous section with the exception of calling USBDBulkCompositeInit() instead of USBDBulkInit(). This will prepare an instance of the bulk device class to be enumerated as part of a composite device. The USBDBulkCompositeInit() function takes the bulk device structure and a pointer to a tCompositeEntry value so that it can properly initialize the bulk device and the composite entry that will later be passed to the USBDCompositeInit() function. The code example below provides an example of how to initialize a bulk device to be a part of a composite device.

```
//
// These should be initialized with valid values for each class.
//
extern tUSBDBulkDevice g_sBulkDevice;
void *pvBulkDevice;

//
// The array of composite devices.
//
tCompositeEntry psCompEntries[2];

//
// Allocate the device data for the top level composite device class.
//
tUSBDCompositeDevice g_sCompDevice =
{
    //
    // Texas Intruments C-Series VID.
    //
    USB_VID_TI_1CBE,

    //
    // Texas Intruments C-Series PID for composite serial device.
    //
    USB_PID_YOUR_COMPOSITE_PID,

    //
```

```
    // This is in 2mA increments so 500mA.
    //
    250,

    //
    // Bus powered device.
    //
    USB_CONF_ATTR_BUS_PWR,

    //
    // Composite event handler.
    //
    EventHandler,

    //
    // The string table.
    //
    g_pui8StringDescriptors,
    NUM_STRING_DESCRIPTORS,

    //
    // The Composite device array.
    //
    2,
    g_psCompEntries
};

//
// The OTHER_SIZES here are the sizes of the descriptor data for other classes
// that are part of the composite device.
//
#define DESCRIPTOR_DATA_SIZE    (COMPOSITE_DBULK_SIZE + OTHER_SIZES)
uint8_t g_pui8DescriptorData[DESCRIPTOR_DATA_SIZE];

//
// Initialize the bulk device and its composite entry.
//
pvBulkDevice = USBDBulkCompositeInit(0, &g_sBulkDevice, &psCompEntries[0]);

//
// Initialize other devices to add to the composite device.
//

...

//
// Initialize the USB controller as a composite device.
//
USBDCompositeInit(0, &g_sCompDevice, DESCRIPTOR_DATA_SIZE,
                  g_pui8DescriptorData);
```

All other API calls to the USB bulk device class should use the value returned by USBDBulkCompositeInit() when the API calls for a pvInstance pointer. Also when using the bulk device in a composite device the **COMPOSITE_DBULK_SIZE** value should be added to the size of the g_pui8DescriptorData array as shown in the example above.

2.5.4 Windows Drivers for Generic Bulk Devices

Since generic bulk devices appear to a host operating system as vendor-specific devices, no device drivers on the host system will be able to communicate with them without some help from the device developer. This help may involve writing a specific Windows kernel driver for the device or, if kernel driver programming is too daunting, steering Windows to use one of several possible generic kernel drivers that can manage the device on behalf of a user mode application.

Using this second model, a device developer need not write any Windows driver code but would need to write an application or DLL that interfaces with the device via the user-mode API offered by whichever USB subsystem they chose to manage their device. The developer is also responsible for producing a suitable INF file to allow Windows to associate the device (identified via its VID/PID combination) with a particular driver.

A least two suitable USB subsystems are available for Windows - WinUSB from Microsoft or open-source project libusb-win32 available from SourceForge.

WinUSB supports WindowsXP, Windows Vista and Windows7 systems. Further information can be obtained from MSDN at http://msdn.microsoft.com/en-us/library/aa476426.aspx. To develop applications using the WinUSB interface, the Windows Driver Development Kit (DDK) must be installed on your build PC. This interface is currently used by the Windows example applications, "Oscilloscope" and "USB Bulk Example". These applications can be found in package "PDL-LM3S-win" which may be downloaded via a link on http://www.ti.com/tivaware.

libusb-win32 supports Windows98SE, Windows2000, WindowsNT and WindowsXP and can be downloaded from http://libusb-win32.sourceforge.net/. It offers a straightforward method of accessing the device and also provides a very helpful INF file generator.

2.5.4.1 Sample WinUSB INF file

This file illustrates how to build an INF to associate your device with the WinUSB subsystem on WindowsXP or Vista. Note that the driver package for the device must include not only this INF file but the Microsoft-supplied coinstallers listed in the files section. These can be found within the Windows Driver Development Kit (DDK).

```
; ------------------------------------------------------------------------------
;
; USBLib Generic Bulk USB device driver installer
;
; This INF file may be used as a template when creating customized applications
; based on the USBLib generic bulk devices. Areas of the file requiring
; customization for a new device are commented with NOTEs.
;
; ------------------------------------------------------------------------------

; NOTE: When you customize this INF for your own device, create a new class
; name (Class) and a new GUID (ClassGuid). GUIDs may be created using the
```

```
; guidgen tool from Windows Visual Studio.

[Version]
Signature = "$Windows NT$"
Class = USBLibBulkDeviceClass
ClassGuid={F5450C06-EB58-420e-8F98-A76C5D4AFB18}
Provider = %ProviderName%
CatalogFile=MyCatFile.cat

; ========== Manufacturer/Models sections ===========

[Manufacturer]
%ProviderName% = USBLibBulkDevice_WinUSB,NTx86,NTamd64

; NOTE: Replace the VID and PID in the following two sections with the
; correct values for your device.

[USBLibBulkDevice_WinUSB.NTx86]
%USB\USBLibBulkDevice.DeviceDesc% =USB_Install, USB\VID_1CBE&PID_0003

[USBLibBulkDevice_WinUSB.NTamd64]
%USB\USBLibBulkDevice.DeviceDesc% =USB_Install, USB\VID_1CBE&PID_0003

; ================== Installation ==================

[ClassInstall32]
AddReg=AddReg_ClassInstall

[AddReg_ClassInstall]
HKR,,,,"%DeviceClassDisplayName%"
HKR,,Icon,,"-20"

[USB_Install]
Include=winusb.inf
Needs=WINUSB.NT

[USB_Install.Services]
Include=winusb.inf
AddService=WinUSB,0x00000002,WinUSB_ServiceInstall

[WinUSB_ServiceInstall]
DisplayName     = %WinUSB_SvcDesc%
ServiceType     = 1
StartType       = 3
ErrorControl    = 1
ServiceBinary   = %12%\WinUSB.sys

[USB_Install.Wdf]
KmdfService=WINUSB, WinUsb_Install

[WinUSB_Install]
KmdfLibraryVersion=1.5
```

```
[USB_Install.HW]
AddReg=Dev_AddReg

; NOTE: Create a new GUID for your interface and replace the following one
; when customizing for a new device.

[Dev_AddReg]
HKR,,DeviceInterfaceGUIDs,0x10000,"{6E45736A-2B1B-4078-B772-B3AF2B6FDE1C}"

[USB_Install.CoInstallers]
AddReg=CoInstallers_AddReg
CopyFiles=CoInstallers_CopyFiles

[CoInstallers_AddReg]
HKR,,CoInstallers32,0x00010000,"WdfCoInstaller01005.dll,WdfCoInstaller","WinUSBCoIn

[CoInstallers_CopyFiles]
WinUSBCoInstaller.dll
WdfCoInstaller01005.dll

[DestinationDirs]
CoInstallers_CopyFiles=11

; ================= Source Media Section =====================

[SourceDisksNames]
1 = %DISK_NAME%,,,\i386
2 = %DISK_NAME%,,,\amd64

[SourceDisksFiles.x86]
WinUSBCoInstaller.dll=1
WdfCoInstaller01005.dll=1

[SourceDisksFiles.amd64]
WinUSBCoInstaller.dll=2
WdfCoInstaller01005.dll=2

; ================== Strings ==================

; Note: Replace these as appropriate to describe your device.

[Strings]
ProviderName="Texas Instruments"
USB\USBLibBulkDevice.DeviceDesc="Generic Bulk Device"
WinUSB_SvcDesc="WinUSB"
DISK_NAME="USBLib Install Disk"
DeviceClassDisplayName="USBLib Bulk Devices"
```

2.5.4.2 Sample libusb-win32 INF File

The following is an example of an INF file that can be used to associate the `usb_ex4_dev_bulk` C28x example `usb_ex4_dev_bulk_cm` for CM and device with the libusb-win32 subsystem on Windows systems and to install the necessary drivers. This was created using the "INF Wizard" application which is included in the libusb-win32 download package.

```
[Version]
Signature = "$Chicago$"
provider  = %manufacturer%
DriverVer = 03/20/2007,0.1.12.1
CatalogFile = usb_dev_bulk_libusb.cat
CatalogFile.NT = usb_dev_bulk_libusb.cat
CatalogFile.NTAMD64 = usb_dev_bulk_libusb_x64.cat

Class = LibUsbDevices
ClassGUID = {EB781AAF-9C70-4523-A5DF-642A87ECA567}

[ClassInstall]
AddReg=libusb_class_install_add_reg

[ClassInstall32]
AddReg=libusb_class_install_add_reg

[libusb_class_install_add_reg]
HKR,,,,"LibUSB-Win32 Devices"
HKR,,Icon,,"-20"

[Manufacturer]
%manufacturer%=Devices,NT,NTAMD64

;------------------------------------------------------------------------
; Files
;------------------------------------------------------------------------

[SourceDisksNames]
1 = "Libusb-Win32 Driver Installation Disk",,

[SourceDisksFiles]
libusb0.sys = 1,,
libusb0.dll = 1,,
libusb0_x64.sys = 1,,
libusb0_x64.dll = 1,,

[DestinationDirs]
libusb_files_sys = 10,system32\drivers
libusb_files_sys_x64 = 10,system32\drivers
libusb_files_dll = 10,system32
libusb_files_dll_wow64 = 10,syswow64
libusb_files_dll_x64 = 10,system32

[libusb_files_sys]
```

```
libusb0.sys

[libusb_files_sys_x64]
libusb0.sys,libusb0_x64.sys

[libusb_files_dll]
libusb0.dll

[libusb_files_dll_wow64]
libusb0.dll

[libusb_files_dll_x64]
libusb0.dll,libusb0_x64.dll

;------------------------------------------------------------------------------
; Device driver
;------------------------------------------------------------------------------

[LIBUSB_DEV]
CopyFiles = libusb_files_sys, libusb_files_dll
AddReg    = libusb_add_reg

[LIBUSB_DEV.NT]
CopyFiles = libusb_files_sys, libusb_files_dll

[LIBUSB_DEV.NTAMD64]
CopyFiles = libusb_files_sys_x64, libusb_files_dll_wow64, libusb_files_dll_x64

[LIBUSB_DEV.HW]
DelReg = libusb_del_reg_hw
AddReg = libusb_add_reg_hw

[LIBUSB_DEV.NT.HW]
DelReg = libusb_del_reg_hw
AddReg = libusb_add_reg_hw

[LIBUSB_DEV.NTAMD64.HW]
DelReg = libusb_del_reg_hw
AddReg = libusb_add_reg_hw

[LIBUSB_DEV.NT.Services]
AddService = libusb0, 0x00000002, libusb_add_service

[LIBUSB_DEV.NTAMD64.Services]
AddService = libusb0, 0x00000002, libusb_add_service

[libusb_add_reg]
HKR,,DevLoader,,*ntkern
HKR,,NTMPDriver,,libusb0.sys

; Older versions of this .inf file installed filter drivers. They are not
; needed any more and must be removed
```

```
[libusb_del_reg_hw]
HKR,,LowerFilters
HKR,,UpperFilters

; Device properties
[libusb_add_reg_hw]
HKR,,SurpriseRemovalOK, 0x00010001, 1

;------------------------------------------------------------------------
; Services
;------------------------------------------------------------------------

[libusb_add_service]
DisplayName    = "LibUsb-Win32 - Kernel Driver 03/20/2007, 0.1.12.1"
ServiceType    = 1
StartType      = 3
ErrorControl   = 0
ServiceBinary  = %12%\libusb0.sys

;------------------------------------------------------------------------
; Devices
;------------------------------------------------------------------------

[Devices]
"Generic Bulk Device"=LIBUSB_DEV, USB\VID_1cbe&PID_0003

[Devices.NT]
"Generic Bulk Device"=LIBUSB_DEV, USB\VID_1cbe&PID_0003

[Devices.NTAMD64]
"Generic Bulk Device"=LIBUSB_DEV, USB\VID_1cbe&PID_0003


;------------------------------------------------------------------------
; Strings
;------------------------------------------------------------------------

[Strings]
manufacturer = "Texas Instruments"
```

2.6 Bulk Device Class Driver Definitions

Data Structures

- tUSBDBulkDevice

Defines

- COMPOSITE_DBULK_SIZE

Functions

- void * USBDBulkCompositeInit (uint32_t ui32Index, tUSBDBulkDevice *psBulkDevice, tCompositeEntry *psCompEntry)
- void * USBDBulkInit (uint32_t ui32Index, tUSBDBulkDevice *psBulkDevice)
- uint32_t USBDBulkPacketRead (void *pvBulkDevice, uint8_t *pi8Data, uint32_t ui32Length, bool bLast)
- uint32_t USBDBulkPacketWrite (void *pvBulkDevice, uint8_t *pi8Data, uint32_t ui32Length, bool bLast)
- void USBDBulkPowerStatusSet (void *pvBulkDevice, uint8_t ui8Power)
- bool USBDBulkRemoteWakeupRequest (void *pvBulkDevice)
- uint32_t USBDBulkRxPacketAvailable (void *pvBulkDevice)
- void * USBDBulkSetRxCBData (void *pvBulkDevice, void *pvCBData)
- void * USBDBulkSetTxCBData (void *pvBulkDevice, void *pvCBData)
- void USBDBulkTerm (void *pvBulkDevice)
- uint32_t USBDBulkTxPacketAvailable (void *pvBulkDevice)

2.6.1 Detailed Description

The macros and functions defined in this section can be found in header file `device/usbdbulk.h`.

2.6.2 Data Structure Documentation

2.6.2.1 tUSBDBulkDevice

Definition:

```
typedef struct
{
    const uint16_t ui16VID;
    const uint16_t ui16PID;
    const uint16_t ui16MaxPowermA;
    const uint8_t ui8PwrAttributes;
    tUSBCallbackconst pfnRxCallback;
    void *pvRxCBData;
    tUSBCallbackconst pfnTxCallback;
    void *pvTxCBData;
    const uint8_t *const *ppui8StringDescriptors;
    const uint32_t ui32NumStringDescriptors;
    tBulkInstance sPrivateData;
}
tUSBDBulkDevice
```

Members:

ui16VID The vendor ID that this device is to present in the device descriptor.

ui16PID The product ID that this device is to present in the device descriptor.

ui16MaxPowermA The maximum power consumption of the device, expressed in milliamps.

ui8PwrAttributes Indicates whether the device is self- or bus-powered and whether or not it supports remote wakeup. Valid values are USB_CONF_ATTR_SELF_PWR or USB_CONF_ATTR_BUS_PWR, optionally ORed with USB_CONF_ATTR_RWAKE.

pfnRxCallback A pointer to the callback function which will be called to notify the application of events related to the device's data receive channel.

pvRxCBData A client-supplied pointer which will be sent as the first parameter in all calls made to the receive channel callback, pfnRxCallback.

pfnTxCallback A pointer to the callback function which will be called to notify the application of events related to the device's data transmit channel.

pvTxCBData A client-supplied pointer which will be sent as the first parameter in all calls made to the transmit channel callback, pfnTxCallback.

ppui8StringDescriptors A pointer to the string descriptor array for this device. This array must contain pointers to the following string descriptors in this order. Language descriptor, Manufacturer name string (language 1), Product name string (language 1), Serial number string (language 1), Interface description string (language 1) and Configuration description string (language 1).
If supporting more than 1 language, the strings for indices 1 through 5 must be repeated for each of the other languages defined in the language descriptor.

ui32NumStringDescriptors The number of descriptors provided in the ppStringDescriptors array. This must be 1 + (5 * number of supported languages).

sPrivateData The private instance data for this device. This memory must not be modified by any code outside the bulk class driver.

Description:
The structure used by the application to define operating parameters for the bulk device.

2.6.3 Define Documentation

2.6.3.1 COMPOSITE_DBULK_SIZE

Definition:
```
#define COMPOSITE_DBULK_SIZE
```

Description:
The size of the memory that should be allocated to create a configuration descriptor for a single instance of the USB Bulk Device. This does not include the configuration descriptor which is automatically ignored by the composite device class.

2.6.4 Function Documentation

2.6.4.1 USBDBulkCompositeInit

Initializes bulk device operation for a given USB controller.

Prototype:
```
void *
USBDBulkCompositeInit(uint32_t ui32Index,
                      tUSBDBulkDevice *psBulkDevice,
                      tCompositeEntry *psCompEntry)
```

Parameters:
ui32Index is the index of the USB controller which is to be initialized for bulk device operation.

psBulkDevice points to a structure containing parameters customizing the operation of the bulk device.

psCompEntry is the composite device entry to initialize when creating a composite device.

Description:

This call is very similar to USBDBulkInit() except that it is used for initializing an instance of the bulk device for use in a composite device. When this bulk device is part of a composite device, then the *psCompEntry* should point to the composite device entry to initialize. This is part of the array that is passed to the USBDCompositeInit() function.

Returns:

Returns zero on failure or a non-zero value that should be used with the remaining USB Bulk APIs.

2.6.4.2 USBDBulkInit

Initializes bulk device operation for a given USB controller.

Prototype:

```
void *
USBDBulkInit(uint32_t ui32Index,
             tUSBDBulkDevice *psBulkDevice)
```

Parameters:

ui32Index is the index of the USB controller which is to be initialized for bulk device operation.

psBulkDevice points to a structure containing parameters customizing the operation of the bulk device.

Description:

An application wishing to make use of a USB bulk communication channel must call this function to initialize the USB controller and attach the device to the USB bus. This function performs all required USB initialization.

On successful completion, this function will return the *psBulkDevice* pointer passed to it. This must be passed on all future calls to the device driver related to this device.

The USBDBulk interface offers packet-based transmit and receive operation. If the application would rather use block based communication with transmit and receive buffers, USB buffers may be used above the bulk transmit and receive channels to offer this functionality.

Transmit Operation:

Calls to USBDBulkPacketWrite must send no more than 64 bytes of data at a time and may only be made when no other transmission is currently outstanding.

Once a packet of data has been acknowledged by the USB host, a **USB_EVENT_TX_COMPLETE** event is sent to the application callback to inform it that another packet may be transmitted.

Receive Operation:

An incoming USB data packet will result in a call to the application callback with event **USBD_EVENT_RX_AVAILABLE**. The application must then call USBDBulkPacketRead(), passing a buffer capable of holding 64 bytes, to retrieve the data and acknowledge reception to the USB host.

Note:
The application must not make any calls to the low level USB Device API if interacting with USB via the USB bulk device class API. Doing so will cause unpredictable (though almost certainly unpleasant) behavior.

Returns:
Returns NULL on failure or void pointer that should be used with the remaining USB bulk class APSs.

2.6.4.3 USBDBulkPacketRead

Reads a packet of data received from the USB host via the bulk data interface.

Prototype:
```
uint32_t
USBDBulkPacketRead(void *pvBulkDevice,
                   uint8_t *pi8Data,
                   uint32_t ui32Length,
                   bool bLast)
```

Parameters:
pvBulkDevice is the pointer to the device instance structure as returned by USBDBulkInit().

pi8Data points to a buffer into which the received data will be written.

ui32Length is the size of the buffer pointed to by pi8Data.

bLast indicates whether the client will make a further call to read additional data from the packet.

Description:
This function reads up to *ui32Length* bytes of data received from the USB host into the supplied application buffer. If the driver detects that the entire packet has been read, it is acknowledged to the host.

The *bLast* parameter is ignored in this implementation since the end of a packet can be determined without relying upon the client to provide this information.

Returns:
Returns the number of bytes of data read.

2.6.4.4 USBDBulkPacketWrite

Transmits a packet of data to the USB host via the bulk data interface.

Prototype:
```
uint32_t
USBDBulkPacketWrite(void *pvBulkDevice,
                    uint8_t *pi8Data,
                    uint32_t ui32Length,
                    bool bLast)
```

Parameters:
pvBulkDevice is the pointer to the device instance structure as returned by USBDBulkInit().

pi8Data points to the first byte of data which is to be transmitted.

ui32Length is the number of bytes of data to transmit.

bLast indicates whether more data is to be written before a packet should be scheduled for transmission. If **true**, the client will make a further call to this function. If **false**, no further call will be made and the driver should schedule transmission of a short packet.

Description:

This function schedules the supplied data for transmission to the USB host in a single USB packet. If no transmission is currently ongoing, the data is immediately copied to the relevant USB endpoint FIFO for transmission. Whenever a USB packet is acknowledged by the host, a **USB_EVENT_TX_COMPLETE** event will be sent to the transmit channel callback indicating that more data can now be transmitted.

The maximum value for *ui32Length* is 64 bytes (the maximum USB packet size for the bulk endpoints in use by the device). Attempts to send more data than this will result in a return code of 0 indicating that the data cannot be sent.

The *bLast* parameter allows a client to make multiple calls to this function before scheduling transmission of the packet to the host. This can be helpful if, for example, constructing a packet on the fly or writing a packet which spans the wrap point in a ring buffer.

Returns:

Returns the number of bytes actually sent. At this level, this will either be the number of bytes passed (if less than or equal to the maximum packet size for the USB endpoint in use and no outstanding transmission ongoing) or 0 to indicate a failure.

2.6.4.5 USBDBulkPowerStatusSet

Reports the device power status (bus- or self-powered) to the USB library.

Prototype:

```
void
USBDBulkPowerStatusSet(void *pvBulkDevice,
                       uint8_t ui8Power)
```

Parameters:

pvBulkDevice is the pointer to the bulk device instance structure.

ui8Power indicates the current power status, either **USB_STATUS_SELF_PWR** or **USB_STATUS_BUS_PWR**.

Description:

Applications which support switching between bus- or self-powered operation should call this function whenever the power source changes to indicate the current power status to the USB library. This information is required by the USB library to allow correct responses to be provided when the host requests status from the device.

Returns:

None.

2.6.4.6 USBDBulkRemoteWakeupRequest

Requests a remote wake up to resume communication when in suspended state.

Prototype:

```
bool
USBDBulkRemoteWakeupRequest(void *pvBulkDevice)
```

Parameters:

pvBulkDevice is the pointer to the bulk device instance structure.

Description:

When the bus is suspended, an application which supports remote wake up (advertised to the host via the configuration descriptor) may call this function to initiate remote wake up signaling to the host. If the remote wake up feature has not been disabled by the host, this will cause the bus to resume operation within 20mS. If the host has disabled remote wake up, **false** will be returned to indicate that the wake up request was not successful.

Returns:

Returns **true** if the remote wake up is not disabled and the signaling was started or **false** if remote wake up is disabled or if signaling is currently ongoing following a previous call to this function.

2.6.4.7 USBDBulkRxPacketAvailable

Determines whether a packet is available and, if so, the size of the buffer required to read it.

Prototype:

```
uint32_t
USBDBulkRxPacketAvailable(void *pvBulkDevice)
```

Parameters:

pvBulkDevice is the pointer to the device instance structure as returned by USBDBulkInit().

Description:

This function may be used to determine if a received packet remains to be read and allows the application to determine the buffer size needed to read the data.

Returns:

Returns 0 if no received packet remains unprocessed or the size of the packet if a packet is waiting to be read.

2.6.4.8 USBDBulkSetRxCBData

Sets the client-specific pointer parameter for the receive channel callback.

Prototype:

```
void *
USBDBulkSetRxCBData(void *pvBulkDevice,
                    void *pvCBData)
```

Parameters:

pvBulkDevice is the pointer to the device instance structure as returned by USBDBulkInit().

pvCBData is the pointer that client wishes to be provided on each event sent to the receive channel callback function.

Description:

The client uses this function to change the callback pointer passed in the first parameter on all callbacks to the *pfnRxCallback* function passed on USBDBulkInit().

If a client wants to make runtime changes in the callback pointer, it must ensure that the *pvBulkDevice* structure passed to USBDBulkInit() resides in RAM. If this structure is in flash, callback pointer changes are not possible.

Returns:

Returns the previous callback pointer that was being used for this instance's receive callback.

2.6.4.9 USBDBulkSetTxCBData

Sets the client-specific pointer parameter for the transmit callback.

Prototype:

```
void *
USBDBulkSetTxCBData(void *pvBulkDevice,
                    void *pvCBData)
```

Parameters:

pvBulkDevice is the pointer to the device instance structure as returned by USBDBulkInit().

pvCBData is the pointer that client wishes to be provided on each event sent to the transmit channel callback function.

Description:

The client uses this function to change the callback pointer passed in the first parameter on all callbacks to the *pfnTxCallback* function passed on USBDBulkInit().

If a client wants to make runtime changes in the callback pointer, it must ensure that the *pvBulkDevice* structure passed to USBDBulkInit() resides in RAM. If this structure is in flash, callback pointer changes are not possible.

Returns:

Returns the previous callback pointer that was being used for this instance's transmit callback.

2.6.4.10 USBDBulkTerm

Shut down the bulk device.

Prototype:

```
void
USBDBulkTerm(void *pvBulkDevice)
```

Parameters:

pvBulkDevice is the pointer to the device instance structure as returned by USBDBulkInit().

Description:

This function terminates device operation for the instance supplied and removes the device from the USB bus. This function should not be called if the bulk device is part of a composite device and instead the USBDCompositeTerm() function should be called for the full composite device.

Following this call, the *pvBulkDevice* instance should not me used in any other calls.

Returns:
None.

2.6.4.11 USBDBulkTxPacketAvailable

Returns the number of free bytes in the transmit buffer.

Prototype:
```
uint32_t
USBDBulkTxPacketAvailable(void *pvBulkDevice)
```

Parameters:
pvBulkDevice is the pointer to the device instance structure as returned by USBDBulkInit().

Description:
This function returns the maximum number of bytes that can be passed on a call to USBDBulkPacketWrite and accepted for transmission. The value returned will be the maximum USB packet size (64) if no transmission is currently outstanding or 0 if a transmission is in progress.

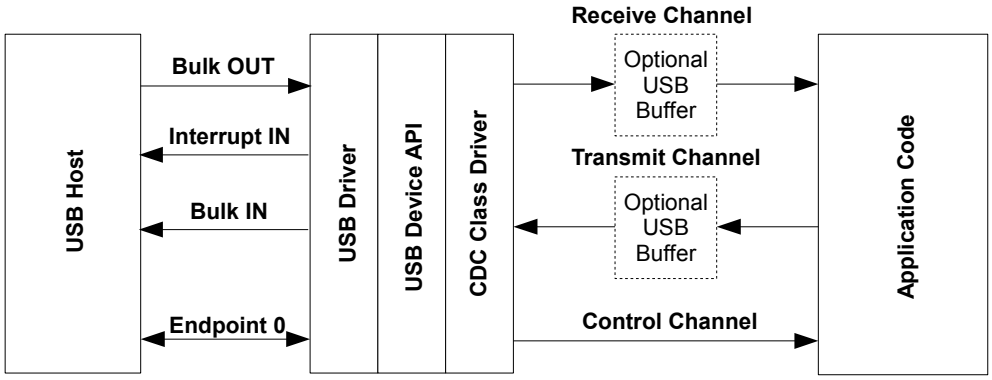
Returns:
Returns the number of bytes available in the transmit buffer.

2.7 CDC Device Class Driver

The USB Communication Device Class (CDC) class driver supports the CDC Abstract Control Model variant and allows a client application to be seen as a virtual serial port to the USB host system. The driver provides two channels, one transmit and one receive. The channels may be used in conjunction with USB buffers to provide a simple read/write interface for data transfer to and from the host. Additional APIs and events are used to support serial-link-specific operations such as notification of UART errors, sending break conditions and setting communication line parameters.

The data transmission capabilities of this device class driver are very similar to the generic bulk class but, since this is a standard device class, the host operating system will likely be able to access the device without the need for any special additional device drivers. On Windows, for example, a simple INF file is all that is required to make the USB device appear as a COM port which can be accessed by any serial terminal application.

USB CDC Device Model



This device class uses three endpoints in addition to endpoint zero. Two bulk endpoints carry data to and from the host and an interrupt IN endpoint is used to signal any serial errors such as break, framing error or parity error detected by the device. Endpoint zero carries standard USB requests and also CDC-specific requests which translate to events passed to the application via the control channel callback.

The C28x side `usb_ex1_dev_serial` example application and CM side `usb_ex1_device_serial_cm` example application makes use of this device class driver.

2.7.1 CDC Device Class Events

The CDC device class driver sends the following events to the application callback functions:

2.7.1.1 Receive Channel Events

- **USB_EVENT_RX_AVAILABLE**
- **USB_EVENT_DATA_REMAINING**
- **USB_EVENT_ERROR**

2.7.1.2 Transmit Channel Events

- **USB_EVENT_TX_COMPLETE**

2.7.1.3 Control Channel Events

- **USB_EVENT_CONNECTED**
- **USB_EVENT_DISCONNECTED**
- **USB_EVENT_SUSPEND**

- **USB_EVENT_RESUME**
- **USBD_CDC_EVENT_SEND_BREAK**
- **USBD_CDC_EVENT_CLEAR_BREAK**
- **USBD_CDC_EVENT_SET_LINE_CODING**
- **USBD_CDC_EVENT_GET_LINE_CODING**
- **USBD_CDC_EVENT_SET_CONTROL_LINE_STATE**

Note: The USB_EVENT_DISCONNECTED event will not be reported to the application if the MCU's PB1/USB0VBUS pin is connected to a fixed +5 Volts rather than directly to the VBUS pin on the USB connector or if the USB controller is configured to force device mode.

2.7.2 Using the CDC Device Class Driver

To add USB CDC data transmit and receive capability to your application via the CDC Device Class Driver, take the following steps.

- Add the following header files to the source file(s) which are to support USB:

```
#include "usb.h"
#include "include/usblib.h"
#include "include/device/usbdevice.h"
#include "include/device/usbdcdc.h"
```

- Define the 6 entry string descriptor table which is used to describe various features of your new device to the host system. The following is the string table taken from the C28x side `usb_ex1_dev_serial` example application and CM side `usb_ex1_device_serial_cm` example application. Edit the actual strings to suit your application and take care to ensure that you also update the length field (the first byte) of each descriptor to correctly reflect the length of the string and descriptor header. The number of string descriptors you include must be (1 + (5 ∗ num languages)) where the number of languages agrees with the list published in string descriptor 0, *g_pui8LangDescriptor*. The strings for each language must be grouped together with all the language 1 strings before all the language 2 strings and so on.

```
//*****************************************************************************
//
// The languages supported by this device.
//
//*****************************************************************************
const uint8_t g_pui8LangDescriptor[] =
{
    4,
    USB_DTYPE_STRING,
    USBShort(USB_LANG_EN_US)
};

//*****************************************************************************
//
// The manufacturer string.
//
//*****************************************************************************
const uint8_t g_pui8ManufacturerString[] =
```

```
{
    (17 + 1) * 2,
    USB_DTYPE_STRING,
    'T', 0, 'e', 0, 'x', 0, 'a', 0, 's', 0, ' ', 0, 'I', 0, 'n', 0, 's', 0,
    't', 0, 'r', 0, 'u', 0, 'm', 0, 'e', 0, 'n', 0, 't', 0, 's', 0,
};

//*****************************************************************************
//
// The product string.
//
//*****************************************************************************
const uint8_t g_pui8ProdectString[] =
{
    2 + (16 * 2),
    USB_DTYPE_STRING,
    'V', 0, 'i', 0, 'r', 0, 't', 0, 'u', 0, 'a', 0, 'l', 0, ' ', 0,
    'C', 0, 'O', 0, 'M', 0, ' ', 0, 'P', 0, 'o', 0, 'r', 0, 't', 0
};

//*****************************************************************************
//
// The serial number string.
//
//*****************************************************************************
const uint8_t g_pui8SerialNumberString[] =
{
    2 + (8 * 2),
    USB_DTYPE_STRING,
    '1', 0, '2', 0, '3', 0, '4', 0, '5', 0, '6', 0, '7', 0, '8', 0
};

//*****************************************************************************
//
// The control interface description string.
//
//*****************************************************************************
const uint8_t g_pui8ControlInterfaceString[] =
{
    2 + (21 * 2),
    USB_DTYPE_STRING,
    'A', 0, 'C', 0, 'M', 0, ' ', 0, 'C', 0, 'o', 0, 'n', 0, 't', 0,
    'r', 0, 'o', 0, 'l', 0, ' ', 0, 'I', 0, 'n', 0, 't', 0, 'e', 0,
    'r', 0, 'f', 0, 'a', 0, 'c', 0, 'e', 0
};

//*****************************************************************************
//
// The configuration description string.
//
//*****************************************************************************
const uint8_t g_pui8ConfigString[] =
```

```
{
    2 + (26 * 2),
    USB_DTYPE_STRING,
    'S', 0, 'e', 0, 'l', 0, 'f', 0, ' ', 0, 'P', 0, 'o', 0, 'w', 0,
    'e', 0, 'r', 0, 'e', 0, 'd', 0, ' ', 0, 'C', 0, 'o', 0, 'n', 0,
    'f', 0, 'i', 0, 'g', 0, 'u', 0, 'r', 0, 'a', 0, 't', 0, 'i', 0,
    'o', 0, 'n', 0
};

//*****************************************************************************
//
// The descriptor string table.
//
//*****************************************************************************
const uint8_t * const g_pui8StringDescriptors[] =
{
    g_pui8LangDescriptor,
    g_pui8ManufacturerString,
    g_pui8ProdectString,
    g_pui8SerialNumberString,
    g_pui8ControlInterfaceString,
    g_pui8ConfigString
};

#define NUM_STRING_DESCRIPTORS (sizeof(g_pui8StringDescriptors)             /\
                                sizeof(uint8_t *))
```

- Define a *tUSBDCDCDevice* structure and initialize all fields as required for your application. The following example illustrates a simple case where no USB buffers are in use. For an example using USB buffers, see the source file `usb_ex1_serial_structs.c` in the C28x side `usb_ex1_dev_serial` example application and `usb_ex1_device_structs.c` CM side `usb_ex1_device_serial_cm` example application. example application.

```
const tUSBDCDCDevice g_sCDCDevice =
{
    //
    // The Vendor ID you have been assigned by USB-IF.
    //
    USB_VID_YOUR_VENDOR_ID,

    //
    // The product ID you have assigned for this device.
    //
    USB_PID_YOUR_PRODUCT_ID,

    //
    // The power consumption of your device in milliamps.
    //
    POWER_CONSUMPTION_MA,

    //
    // The value to be passed to the host in the USB configuration descriptor's
    // bmAttributes field.
```

```
        //
        USB_CONF_ATTR_SELF_PWR,

        //
        // A pointer to your control callback event handler.
        //
        YourUSBControlEventCallback,

        //
        // A value that you want passed to the control callback alongside every
        // event.
        //
        (void *)&g_sYourInstanceData,

        //
        // A pointer to your receive callback event handler.
        //
        YourUSBReceiveEventCallback,

        //
        // A value that you want passed to the receive callback alongside every
        // event.
        //
        (void *)&g_sYourInstanceData,

        //
        // A pointer to your transmit callback event handler.
        //
        YourUSBTransmitEventCallback,

        //
        // A value that you want passed to the transmit callback alongside every
        // event.
        //
        (void *)&g_sYourInstanceData,

        //
        // A pointer to your string table.
        //
        g_ppui8StringDescriptors,

        //
        // The number of entries in your string table.
        //
        NUM_STRING_DESCRIPTORS
    };
```

- Add a receive event handler function, YourUSBReceiveEventCallback in the previous example, to your application taking care to handle all messages which require a particular response. For the CDC device class, **USB_EVENT_RX_AVAILABLE** and **USB_EVENT_DATA_REMAINING** MUST be handled by the receive event handler.

  In response to **USB_EVENT_RX_AVAILABLE**, your handler should check the amount of data received by calling USBDCDCRxPacketAvailable() then read it using a call to USBDCDCPack-

etRead(). This causes the newly received data to be acknowledged to the host and instructs the host that it may now transmit another packet. If you are unable to read the data immediately, return 0 from the callback handler and you will be called back once again a few milliseconds later.

On **USB_EVENT_DATA_REMAINING** the application should return the number of bytes of data it currently has buffered. This event controls timing of some incoming requests to, for example, send break conditions or change line transmission parameters. These requests are held off until all previously received data has been processed so it is important to ensure that this event returns 0 only once any application buffers are empty.

Although no other events must be handled, **USB_EVENT_CONNECTED** and **USB_EVENT_DISCONNECTED** will typically be required since these indicate when a host connects or disconnects and allow the application to flush any buffers or reset state as required. Attempts to send data when the host is disconnected will fail.

- Add a transmit event handler function, YourUSBTransmitEventCallback in the previous example, to your application taking care to handle all messages which require a particular response. For the CDC device class, there are no events sent to the transmit callback which MUST be handled but applications will usually want to note **USB_EVENT_TX_COMPLETE** since this is an interlock message indicating that the previous packet sent has been acknowledged by the host and a new packet can now be sent.
- Add a control event handler function, YourUSBControlEventCallback in the previous example, to your application and ensure that you handle **USBD_CDC_EVENT_GET_LINE_CODING**, returning a valid line coding configuration even if your device is not actually driving a UART. Handle the other control events as required for your application.
- From your main initialization function call the CDC device class driver initialization function to configure the USB controller and place the device on the bus.

```
pvDevice = USBDCDCInit(0, &g_sCDCDevice);
```

- Assuming *pvDevice* returned is not NULL, your device is now ready to communicate with a USB host.
- Once the host connects, your control event handler will be sent **USB_EVENT_CONNECTED** and the first packet of data may be sent to the host using USBDCDCPacketWrite() with following packets transmitted as soon as **USB_EVENT_TX_COMPLETE** is received via the transmit event handler.

2.7.3 Using the Composite CDC Serial Device Class

When using the CDC serial device class in a composite, the configuration of the device is very similar to how it is configured as a non-composite device. Follow all of the configuration steps in the previous section with the exception of calling USBDCDCCompositeInit() instead of USBDCDCInit(). This will prepare an instance of the CDC serial device class to be enumerated as part of a composite device. The USBDCDCCompositeInit() function takes the CDC serial device structure and a pointer to a tCompositeEntry value so that it can properly initialize the CDC serial device and the composite entry that will later be passed to the USBDCompositeInit() function. The code example below provides an example of how to initialize an CDC serial device to be a part of a composite device.

```
//
// These should be initialized with valid values for each class.
//
extern tUSBDCDCDevice g_sCDCDevice;
```

```
    void *pvCDCDevice;

    //
    // The array of composited devices.
    //
    tCompositeEntry psCompEntries[2];

    //
    // Allocate the device data for the top level composite device class.
    //
    tUSBDCompositeDevice g_sCompDevice =
    {
        //
        // Texas Instruments C-Series VID.
        //
        USB_VID_TI_1CBE,

        //
        // Texas Instruments C-Series PID for composite serial device.
        //
        USB_PID_YOUR_COMPOSITE_PID,

        //
        // This is in 2mA increments so 500mA.
        //
        250,

        //
        // Bus powered device.
        //
        USB_CONF_ATTR_BUS_PWR,

        //
        // Composite event handler.
        //
        EventHandler,

        //
        // The string table.
        //
        g_pui8StringDescriptors,
        NUM_STRING_DESCRIPTORS,

        //
        // The Composite device array.
        //
        2,
        g_psCompEntries
    };

    //
    // The OTHER_SIZES here are the sizes of the descriptor data for other classes
```

```
// that are part of the composite device.
//
#define DESCRIPTOR_DATA_SIZE    (COMPOSITE_DCDC_SIZE + OTHER_SIZES)
uint8_t g_pui8DescriptorData[DESCRIPTOR_DATA_SIZE];

//
// Save the instance data for this CDC serial device.
//
pvCDCDevice = USBDCDCCompositeInit(0, &g_sCDCDevice, &psCompEntries[0]);

...

//
// Initialize the USB controller as a composite device.
//
USBDCompositeInit(0, &g_sCompDevice, DESCRIPTOR_DATA_SIZE,
                      g_pui8DescriptorData);
```

All other API calls to the USB CDC serial device class should use the value returned by USBDCDCCompositeInit() when the API calls for a pvInstance pointer. Also when using the CDC serial device in a composite device the **COMPOSITE_DCDC_SIZE** value should be added to the size of the g_pui8DescriptorData array as shown in the example above.

2.7.4 Windows Drivers for CDC Serial Devices

Making your CDC serial) device visible as a virtual COM port on a Windows system is very straightforward since Windows already includes a device driver supporting USB CDC devices. The device developer must merely provide a single INF file to associate the VID and PID of the new device with the Windows USB CDC driver, `usbser.sys`. When using the serial device in a composite device it is important to remember to append &MI_xx value to the VID/PID entry as shown in the example below. The actual number used with the MI_* value is the interface number assigned to the serial device. An example INF file is provided below. Unlike the case for the generic bulk device class, no additional installation files are necessary since the CDC serial driver is already installed by default and does not, therefore, have to be redistributed by the device developer.

```
;
;   Texas Instruments USBLib USB CDC (serial) driver installation file.
;
[Version]
Signature="$Windows NT$"
Class=Ports
ClassGuid={4D36E978-E325-11CE-BFC1-08002BE10318}
Provider=%MFGNAME%
LayoutFile=layout.inf
DriverVer=08/17/2001,5.1.2600.0

[Manufacturer]
%MFGNAME%=DeviceList

[DestinationDirs]
DefaultDestDir=12
```

```
[SourceDisksFiles]

[SourceDisksNames]

;
; NOTE: Change the VID and PID in the following section to match your device.
; The values with the &MI_xx values are for the composite serial devices
; examples.
;

[DeviceList]
;
; This entry is for the single serial port example usb_dev_serial.
;
%DESCRIPTION_0%=DriverInstall,USB\VID_1CBE&PID_0002

;
; These entries are for the dual serial port composite example usb_dev_cserial.
;
%DESCRIPTION_0%=DriverInstall,USB\VID_1CBE&PID_0007&MI_00
%DESCRIPTION_1%=DriverInstall,USB\VID_1CBE&PID_0007&MI_01

;
; This entry is for the composite hid/serial device usb_dev_chidcdc.  Notice
; that the value is MI_01 because the serial device is on interface 1.
;
%DESCRIPTION_1%=DriverInstall,USB\VID_1CBE&PID_0009&MI_01

;------------------------------------------------------------------------------
;  Windows XP/2000 Sections
;------------------------------------------------------------------------------

[DriverInstall.nt]
CopyFiles=DriverCopyFiles
AddReg=DriverInstall.nt.AddReg

[DriverCopyFiles]
usbser.sys,,,0x20

[DriverInstall.nt.AddReg]
HKR,,DevLoader,,*ntkern
HKR,,NTMPDriver,,usbser.sys
HKR,,EnumPropPages32,,"MsPorts.dll,SerialPortPropPageProvider"

[DriverInstall.nt.Services]
AddService=usbser, 0x00000002, DriverService

[DriverService]
DisplayName=%SERVICE%
ServiceType=1
StartType=3
```

```
ErrorControl=1
ServiceBinary=%12%\usbser.sys

;------------------------------------------------------------------------------
;  String Definitions (change for your device)
;------------------------------------------------------------------------------

[Strings]
MFGNAME       = "Texas Instruments"
DESCRIPTION_0 = "USB Serial Port"
DESCRIPTION_1 = "USB Serial Command Port"
SERVICE       = "USB CDC serial port"
```

2.8 CDC Device Class Driver Definitions

Data Structures

- tLineCoding
- tUSBDCDCDevice

Defines

- COMPOSITE_DCDC_SIZE
- USBD_CDC_EVENT_CLEAR_BREAK
- USBD_CDC_EVENT_GET_LINE_CODING
- USBD_CDC_EVENT_SEND_BREAK
- USBD_CDC_EVENT_SET_CONTROL_LINE_STATE
- USBD_CDC_EVENT_SET_LINE_CODING

Functions

- void * USBDCDCCompositeInit (uint32_t ui32Index, tUSBDCDCDevice *psCDCDevice, tCompositeEntry *psCompEntry)
- void * USBDCDCInit (uint32_t ui32Index, tUSBDCDCDevice *psCDCDevice)
- uint32_t USBDCDCPacketRead (void *pvCDCDevice, uint8_t *pi8Data, uint32_t ui32Length, bool bLast)
- uint32_t USBDCDCPacketWrite (void *pvCDCDevice, uint8_t *pi8Data, uint32_t ui32Length, bool bLast)
- void USBDCDCPowerStatusSet (void *pvCDCDevice, uint8_t ui8Power)
- bool USBDCDCRemoteWakeupRequest (void *pvCDCDevice)
- uint32_t USBDCDCRxPacketAvailable (void *pvCDCDevice)
- void USBDCDCSerialStateChange (void *pvCDCDevice, uint16_t ui16State)
- void * USBDCDCSetControlCBData (void *pvCDCDevice, void *pvCBData)
- void * USBDCDCSetRxCBData (void *pvCDCDevice, void *pvCBData)
- void * USBDCDCSetTxCBData (void *pvCDCDevice, void *pvCBData)

- void USBDCDCTerm (void *pvCDCDevice)
- uint32_t USBDCDCTxPacketAvailable (void *pvCDCDevice)

2.8.1 Detailed Description

The macros and functions defined in this section can be found in header file `device/usbdcdc.h`. Users of the CDC device class driver will also need to include `usbcdc.h` which contains general CDC definitions required by both host and device implementations.

2.8.2 Data Structure Documentation

2.8.2.1 tLineCoding

Definition:

```
typedef struct
{
    uint32_t ui32Rate;
    uint8_t ui8Stop;
    uint8_t ui8Parity;
    uint8_t ui8Databits;
}
tLineCoding
```

Members:

ui32Rate The data terminal rate in bits per second.

ui8Stop The number of stop bits. Valid values are USB_CDC_STOP_BITS_1, USB_CDC_STOP_BITS_1_5 or USB_CDC_STOP_BITS_2

ui8Parity The parity setting. Valid values are USB_CDC_PARITY_NONE, USB_CDC_PARITY_ODD, USB_CDC_PARITY_EVEN, USB_CDC_PARITY_MARK and USB_CDC_PARITY_SPACE.

ui8Databits The number of data bits per character. Valid values are 5, 6, 7 and 8 in this implementation.

Description:

USB_CDC_GET/SET_LINE_CODING request-specific data.

2.8.2.2 tUSBDCDCDevice

Definition:

```
typedef struct
{
    const uint16_t ui16VID;
    const uint16_t ui16PID;
    const uint16_t ui16MaxPowermA;
    const uint8_t ui8PwrAttributes;
    tUSBCallbackconst pfnControlCallback;
    void *pvControlCBData;
    tUSBCallbackconst pfnRxCallback;
```

```
    void *pvRxCBData;
    tUSBCallbackconst pfnTxCallback;
    void *pvTxCBData;
    const uint8_t *const *ppui8StringDescriptors;
    const uint32_t ui32NumStringDescriptors;
    tCDCSerInstance sPrivateData;
}
tUSBDCDCDevice
```

Members:

ui16VID The vendor ID that this device is to present in the device descriptor.

ui16PID The product ID that this device is to present in the device descriptor.

ui16MaxPowermA The maximum power consumption of the device, expressed in milliamps.

ui8PwrAttributes Indicates whether the device is self- or bus-powered and whether or not it supports remote wakeup. Valid values are USB_CONF_ATTR_SELF_PWR or USB_CONF_ATTR_BUS_PWR, optionally ORed with USB_CONF_ATTR_RWAKE.

pfnControlCallback A pointer to the callback function which will be called to notify the application of all asynchronous control events related to the operation of the device.

pvControlCBData A client-supplied pointer which will be sent as the first parameter in all calls made to the control channel callback, pfnControlCallback.

pfnRxCallback A pointer to the callback function which will be called to notify the application of events related to the device's data receive channel.

pvRxCBData A client-supplied pointer which will be sent as the first parameter in all calls made to the receive channel callback, pfnRxCallback.

pfnTxCallback A pointer to the callback function which will be called to notify the application of events related to the device's data transmit channel.

pvTxCBData A client-supplied pointer which will be sent as the first parameter in all calls made to the transmit channel callback, pfnTxCallback.

ppui8StringDescriptors A pointer to the string descriptor array for this device. This array must contain the following string descriptor pointers in this order. Language descriptor, Manufacturer name string (language 1), Product name string (language 1), Serial number string (language 1), Control interface description string (language 1), Configuration description string (language 1).
If supporting more than 1 language, the strings for indices 1 through 5 must be repeated for each of the other languages defined in the language descriptor.

ui32NumStringDescriptors The number of descriptors provided in the ppStringDescriptors array. This must be 1 + (5 * number of supported languages).

sPrivateData The private instance data for this device. This memory must remain accessible for as long as the CDC device is in use and must not be modified by any code outside the CDC class driver.

Description:

The structure used by the application to define operating parameters for the CDC device.

2.8.3 Define Documentation

2.8.3.1 COMPOSITE_DCDC_SIZE

Definition:

```
#define COMPOSITE_DCDC_SIZE
```

Description:

The size of the memory that should be allocated to create a configuration descriptor for a single instance of the USB Serial CDC Device. This does not include the configuration descriptor which is automatically ignored by the composite device class.

2.8.3.2 USBD_CDC_EVENT_CLEAR_BREAK

Definition:

```
#define USBD_CDC_EVENT_CLEAR_BREAK
```

Description:

The host requests that the device stop sending a BREAK condition on its serial communication channel.

2.8.3.3 USBD_CDC_EVENT_GET_LINE_CODING

Definition:

```
#define USBD_CDC_EVENT_GET_LINE_CODING
```

Description:

The host is querying the current RS232 communication parameters. The pvMsgData parameter points to a tLineCoding structure that the application must fill with the current settings prior to returning from the callback.

2.8.3.4 USBD_CDC_EVENT_SEND_BREAK

Definition:

```
#define USBD_CDC_EVENT_SEND_BREAK
```

Description:

The host requests that the device send a BREAK condition on its serial communication channel. The BREAK should remain active until a USBD_CDC_EVENT_CLEAR_BREAK event is received.

2.8.3.5 USBD_CDC_EVENT_SET_CONTROL_LINE_STATE

Definition:

```
#define USBD_CDC_EVENT_SET_CONTROL_LINE_STATE
```

Description:

The host requests that the device set the RS232 signaling lines to a particular state. The ui32MsgValue parameter contains the RTS and DTR control line states as defined in table 51 of the USB CDC class definition and is a combination of the following values:

(RTS) USB_CDC_DEACTIVATE_CARRIER or USB_CDC_ACTIVATE_CARRIER (DTR) USB_CDC_DTE_NOT_PRESENT or USB_CDC_DTE_PRESENT

2.8.3.6 USBD_CDC_EVENT_SET_LINE_CODING

Definition:

```
#define USBD_CDC_EVENT_SET_LINE_CODING
```

Description:

The host requests that the device set the RS232 communication parameters. The pvMsgData parameter points to a tLineCoding structure defining the required number of bits per character, parity mode, number of stop bits and the baud rate.

2.8.4 Function Documentation

2.8.4.1 USBDCDCCompositeInit

Initializes CDC device operation when used with a composite device.

Prototype:

```
void *
USBDCDCCompositeInit(uint32_t ui32Index,
                     tUSBDCDCDevice *psCDCDevice,
                     tCompositeEntry *psCompEntry)
```

Parameters:

ui32Index is the index of the USB controller in use.

psCDCDevice points to a structure containing parameters customizing the operation of the CDC device.

psCompEntry is the composite device entry to initialize when creating a composite device.

Description:

This call is very similar to USBDCDCInit() except that it is used for initializing an instance of the serial device for use in a composite device. When this CDC serial device is part of a composite device, then the *psCompEntry* should point to the composite device entry to initialize. This is part of the array that is passed to the USBDCompositeInit() function.

Returns:

Returns zero on failure or a non-zero instance value that should be used with the remaining USB CDC APIs.

2.8.4.2 USBDCDCInit

Initializes CDC device operation for a given USB controller.

Prototype:

```
void *
USBDCDCInit(uint32_t ui32Index,
            tUSBDCDCDevice *psCDCDevice)
```

Parameters:

ui32Index is the index of the USB controller which is to be initialized for CDC device operation.

psCDCDevice points to a structure containing parameters customizing the operation of the CDC device.

Description:

An application wishing to make use of a USB CDC communication channel and appear as a virtual serial port on the host system must call this function to initialize the USB controller and attach the device to the USB bus. This function performs all required USB initialization.

The value returned by this function is the *psCDCDevice* pointer passed to it if successful. This pointer must be passed to all later calls to the CDC class driver to identify the device instance.

The USB CDC device class driver offers packet-based transmit and receive operation. If the application would rather use block based communication with transmit and receive buffers, USB buffers on the transmit and receive channels may be used to offer this functionality.

Transmit Operation:

Calls to USBDCDCPacketWrite() must send no more than 64 bytes of data at a time and may only be made when no other transmission is currently outstanding.

Once a packet of data has been acknowledged by the USB host, a **USB_EVENT_TX_COMPLETE** event is sent to the application callback to inform it that another packet may be transmitted.

Receive Operation:

An incoming USB data packet will result in a call to the application callback with event **USB_EVENT_RX_AVAILABLE**. The application must then call USBDCDCPacketRead(), passing a buffer capable of holding the received packet to retrieve the data and acknowledge reception to the USB host. The size of the received packet may be queried by calling USBDCDCRxPacketAvailable().

Note:

The application must not make any calls to the low level USB Device API if interacting with USB via the CDC device class API. Doing so will cause unpredictable (though almost certainly unpleasant) behavior.

Returns:

Returns NULL on failure or the psCDCDevice pointer on success.

2.8.4.3 USBDCDCPacketRead

Reads a packet of data received from the USB host via the CDC data interface.

Prototype:

```
uint32_t
USBDCDCPacketRead(void *pvCDCDevice,
                  uint8_t *pi8Data,
                  uint32_t ui32Length,
                  bool bLast)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

pi8Data points to a buffer into which the received data will be written.

ui32Length is the size of the buffer pointed to by *pi8Data*.

bLast indicates whether the client will make a further call to read additional data from the packet.

Description:

This function reads up to ui32Length bytes of data received from the USB host into the supplied application buffer.

Note:

The *bLast* parameter is ignored in this implementation since the end of a packet can be determined without relying upon the client to provide this information.

Returns:

Returns the number of bytes of data read.

2.8.4.4 USBDCDCPacketWrite

Transmits a packet of data to the USB host via the CDC data interface.

Prototype:

```
uint32_t
USBDCDCPacketWrite(void *pvCDCDevice,
                   uint8_t *pi8Data,
                   uint32_t ui32Length,
                   bool bLast)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

pi8Data points to the first byte of data which is to be transmitted.

ui32Length is the number of bytes of data to transmit.

bLast indicates whether more data is to be written before a packet should be scheduled for transmission. If **true**, the client will make a further call to this function. If **false**, no further call will be made and the driver should schedule transmission of a short packet.

Description:

This function schedules the supplied data for transmission to the USB host in a single USB packet. If no transmission is currently ongoing the data is immediately copied to the relevant USB endpoint FIFO. If the *bLast* parameter is **true**, the newly written packet is then scheduled for transmission. Whenever a USB packet is acknowledged by the host, a **USB_EVENT_TX_COMPLETE** event will be sent to the application transmit callback indicating that more data can now be transmitted.

The maximum value for *ui32Length* is 64 bytes (the maximum USB packet size for the bulk endpoints in use by CDC). Attempts to send more data than this will result in a return code of 0 indicating that the data cannot be sent.

Returns:

Returns the number of bytes actually sent. At this level, this will either be the number of bytes passed (if less than or equal to the maximum packet size for the USB endpoint in use and no outstanding transmission ongoing) or 0 to indicate a failure.

2.8.4.5 USBDCDCPowerStatusSet

Reports the device power status (bus- or self-powered) to the USB library.

Prototype:

```
void
USBDCDCPowerStatusSet(void *pvCDCDevice,
                      uint8_t ui8Power)
```

Parameters:

pvCDCDevice is the pointer to the CDC device instance structure.

ui8Power indicates the current power status, either **USB_STATUS_SELF_PWR** or **USB_STATUS_BUS_PWR**.

Description:

Applications which support switching between bus- or self-powered operation should call this function whenever the power source changes to indicate the current power status to the USB library. This information is required by the USB library to allow correct responses to be provided when the host requests status from the device.

Returns:

None.

2.8.4.6 USBDCDCRemoteWakeupRequest

Requests a remote wakeup to resume communication when in suspended state.

Prototype:

```
bool
USBDCDCRemoteWakeupRequest(void *pvCDCDevice)
```

Parameters:

pvCDCDevice is the pointer to the CDC device instance structure.

Description:

When the bus is suspended, an application which supports remote wakeup (advertised to the host via the configuration descriptor) may call this function to initiate remote wakeup signaling to the host. If the remote wakeup feature has not been disabled by the host, this will cause the bus to resume operation within 20mS. If the host has disabled remote wakeup, **false** will be returned to indicate that the wakeup request was not successful.

Returns:

Returns **true** if the remote wakeup is not disabled and the signaling was started or **false** if remote wakeup is disabled or if signaling is currently ongoing following a previous call to this function.

2.8.4.7 USBDCDCRxPacketAvailable

Determines whether a packet is available and, if so, the size of the buffer required to read it.

Prototype:

```
uint32_t
USBDCDCRxPacketAvailable(void *pvCDCDevice)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

Description:

This function may be used to determine if a received packet remains to be read and allows the application to determine the buffer size needed to read the data.

Returns:

Returns 0 if no received packet remains unprocessed or the size of the packet if a packet is waiting to be read.

2.8.4.8 USBDCDCSerialStateChange

Informs the CDC module of changes in the serial control line states or receive error conditions.

Prototype:

```
void
USBDCDCSerialStateChange(void *pvCDCDevice,
                         uint16_t ui16State)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

ui16State indicates the states of the various control lines and any receive errors detected. Bit definitions are as for the USB CDC SerialState asynchronous notification and are defined in header file usbcdc.h.

Description:

The application should call this function whenever the state of any of the incoming RS232 handshake signals changes or in response to a receive error or break condition. The *ui16State* parameter is the ORed combination of the following flags with each flag indicating the presence of that condition.

- USB_CDC_SERIAL_STATE_OVERRUN
- USB_CDC_SERIAL_STATE_PARITY
- USB_CDC_SERIAL_STATE_FRAMING
- USB_CDC_SERIAL_STATE_RING_SIGNAL
- USB_CDC_SERIAL_STATE_BREAK
- USB_CDC_SERIAL_STATE_TXCARRIER
- USB_CDC_SERIAL_STATE_RXCARRIER

This function should be called only when the state of any flag changes.

Returns:

None.

2.8.4.9 USBDCDCSetControlCBData

Sets the client-specific pointer for the control callback.

Prototype:

```
void *
USBDCDCSetControlCBData(void *pvCDCDevice,
                        void *pvCBData)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

pvCBData is the pointer that client wishes to be provided on each event sent to the control channel callback function.

Description:

The client uses this function to change the callback pointer passed in the first parameter on all callbacks to the *pfnControlCallback* function passed on USBDCDCInit().

If a client wants to make runtime changes in the callback pointer, it must ensure that the psCDCDevice structure passed to USBDCDCInit() resides in RAM. If this structure is in flash, callback pointer changes will not be possible.

Returns:

Returns the previous callback pointer that was being used for this instance's control callback.

2.8.4.10 USBDCDCSetRxCBData

Sets the client-specific data parameter for the receive channel callback.

Prototype:

```
void *
USBDCDCSetRxCBData(void *pvCDCDevice,
                   void *pvCBData)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

pvCBData is the pointer that client wishes to be provided on each event sent to the receive channel callback function.

Description:

The client uses this function to change the callback pointer passed in the first parameter on all callbacks to the *pfnRxCallback* function passed on USBDCDCInit().

If a client wants to make runtime changes in the callback pointer, it must ensure that the psCDCDevice structure passed to USBDCDCInit() resides in RAM. If this structure is in flash, callback data changes will not be possible.

Returns:

Returns the previous callback pointer that was being used for this instance's receive callback.

2.8.4.11 USBDCDCSetTxCBData

Sets the client-specific data parameter for the transmit callback.

Prototype:

```
void *
USBDCDCSetTxCBData(void *pvCDCDevice,
                   void *pvCBData)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

pvCBData is the pointer that client wishes to be provided on each event sent to the transmit channel callback function.

Description:

The client uses this function to change the callback pointer passed in the first parameter on all callbacks to the *pfnTxCallback* function passed on USBDCDCInit().

If a client wants to make runtime changes in the callback pointer, it must ensure that the psCDCDevice structure passed to USBDCDCInit() resides in RAM. If this structure is in flash, callback data changes will not be possible.

Returns:

Returns the previous callback pointer that was being used for this instance's transmit callback.

2.8.4.12 USBDCDCTerm

Shuts down the CDC device instance.

Prototype:

```
void
USBDCDCTerm(void *pvCDCDevice)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

Description:

This function terminates CDC operation for the instance supplied and removes the device from the USB bus. This function should not be called if the CDC device is part of a composite device and instead the USBDCompositeTerm() function should be called for the full composite device.

Following this call, the *pvCDCDevice* instance should not me used in any other calls.

Returns:

None.

2.8.4.13 USBDCDCTxPacketAvailable

Returns the number of free bytes in the transmit buffer.

Prototype:

```
uint32_t
USBDCDCTxPacketAvailable(void *pvCDCDevice)
```

Parameters:

pvCDCDevice is the pointer to the device instance structure as returned by USBDCDCInit().

Description:

This function returns the maximum number of bytes that can be passed on a call to USBDCDCPacketWrite() and accepted for transmission. The value returned will be the maximum USB packet size if no transmission is currently outstanding or 0 if a transmission is in progress.

Returns:

Returns the number of bytes available in the transmit buffer.

2.9 Composite Device Class Driver

The USB composite device class allows classes that are already defined in the USB library to be combined into a single composite device. The device configuration descriptors for the included device classes are merged at run time and returned to the USB host controller during device enumeration as a single composite USB device. Since each device class requires some unique initialization, the device classes provide a separate initialization API that does not touch the USB controller but does perform all other initialization. The initialization of the USB controller is deferred until the USB composite device is initialized and has merged the multiple device configuration descriptors into a single configuration descriptor so that it can properly initialize the USB controller. The endpoint numbers, interface numbers, and string indexes that are included in the device configuration descriptors are modified by the USB composite device class so that the values are valid in the composite device configuration descriptor.

2.9.1 Defining a Composite Device

The USB composite device class is defined at the top level in the tUSBDCompositeDevice structure which is used to describe the class to the USB library. In order for the USB composite device to enumerate and function properly, all members of this structure must be filled with valid information. The usVID and usPID values should have valid Vendor ID and Product ID values for the composite device. The power requirements for the device as specified in the usMaxPowermA and ucPwrAttributes and should take into account the power requirements and settings for all devices classes that the composite device is using. The only truly optional member of the tUSBDCompositeDevice structure is the pfnCallback function which provides notifications to the application that are not handled by the individual device classes. The device specific strings should be included in the ppui8StringDescriptors and *ui32NumStringDescriptors* members. This list of strings should include the following three strings in the following order: Manufacturer, Product, and Product serial number. All other strings used by the classes are specified and are sourced from the included device classes. The psPrivateData should be set to point to a tCompositeInstance structure which provides the composite class with memory for its instance data.

Note: It is important to insure that the microcontroller has enough endpoints to satisfy the number of devices included in the composite class.

Example:

```
uint32_t g_pui32CompWorkspace[NUM_DEVICES];

tUSBDCompositeDevice g_sCompDevice =
```

```
{
    //
    // Vendor ID.
    //
    VENDOR_ID,

    //
    // Product ID.
    //
    VENDOR_PRODUCT_ID,

    //
    // This is in 2mA increments or 500mA.
    //
    250,

    //
    // Bus powered device.
    //
    USB_CONF_ATTR_BUS_PWR,

    //
    // Generic USB handler for the composite device.
    //
    CompositeHandler,

    //
    // The string table.
    //
    g_pStringDescriptors,
    NUM_STRING_DESCRIPTORS,

    //
    // The number of device classes in the composite entry array.
    //
    NUM_DEVICES,
    g_psCompDevices
};
```

2.9.2 Allocating Memory

The USB composite device class requires three different types of memory allocated to properly enumerate and function with the included device classes. The main allocation is a block of memory that is used to build up the combined device configuration descriptor for the combination of the desired device classes. The individual device classes will provide a size in a COMPOSITE_*_SIZE macro that indicates the size in bytes required to hold the configuration descriptor for the device class. This allows the application to provide a large enough buffer to the USBDCompositeInit() function for merging the device descriptors.

2.9.2.1 Defining Device Class Instances

When defining a composite device the application must determine the size of the buffer that is passed into the USBDCompositeInit() function. For example, if a composite device is made up of two serial devices then a buffer of size (COMPOSITE_DCDC_SIZE * 2) should be passed into the initialization routine and an array of that size should be declared in the application.

```
uint8_t pucDesciptorData[COMPOSITE_DCDC_SIZE*2];
```

The application must also allocate separate serial device structure for each instance of the devices that are included in a composite device. This is true even when including two devices classes of the same type are added so that the instances can be differentiated by the USB library. The USB composite device class can determine which instance to use based on the interface number that is accessed by the host controller. The application initializes the data in the array of tCompositeEntry structures passed into the composite initialization for the class.

Example: Two serial instances and the composite device array.

```
extern tUSBDCDCDevice g_sCDCDeviceA;
extern tUSBDCDCDevice g_sCDCDeviceB;

tCompositeEntry g_psDevices[2];
```

2.9.2.2 Interface Handling

The device class interfaces will be merged into the composite device descriptor and the composite class modifies the default interface assignments to insure monotonically increasing indexes for all of the included interfaces. In the example above for the two serial ports, the first serial device would be interface 0 and the second would enumerate as interface 1.

2.9.2.3 String Handling

The device class strings will be merged into the composite device descriptor which will require that the composite class modify the default string indexes. In doing this it will always ignore the three default string indexes in the device descriptor. The remaining string indexes will be modified to match in the configuration descriptor.

2.9.3 Example Composite Device

This section will continue with the example above that used two USB device serial classes in a single device. This will include more detailed examples and code that demonstrate the configuration and setup needed for a composite serial device.

2.9.3.1 Composite Device Instance

The application must first allocate two serial device structures and pass them into the composite initialization function for the USB serial CDC device. The allocation and initialization are shown below:

```
//
// Buffers for serial device A.
//
const tUSBBuffer g_sTxBufferA;
const tUSBBuffer g_sRxBufferA;

//
// Buffers for serial device B.
//
const tUSBBuffer g_sTxBufferB;
const tUSBBuffer g_sRxBufferB;

//
// Device description for Serial Device A.
//
const tUSBDCDCDevice g_sCDCDeviceA =
{
    USB_VID_TI_1CBE,
    USB_PID_SERIAL,
    0,
    USB_CONF_ATTR_SELF_PWR,
    ControlHandler,
    (void *)&g_sCDCDeviceA,
    USBBufferEventCallback,
    (void *)&g_sRxBufferA,
    USBBufferEventCallback,
    (void *)&g_sTxBufferA,
    0,
    0
};

//
// Device description for Serial Device B.
//
const tUSBDCDCDevice g_sCDCDeviceB =
{
    USB_VID_TI_1CBE,
    USB_PID_SERIAL,
    0,
    USB_CONF_ATTR_SELF_PWR,
    ControlHandler,
    (void *)&g_sCDCDeviceB,
    USBBufferEventCallback,
    (void *)&g_sRxBufferB,
    USBBufferEventCallback,
    (void *)&g_sTxBufferB,
    0,
    0
};
```

Now the application must allocate the device array so that it is provided to the USB composite device class. The following code shows the allocation of the composite device array that holds the

data for the two serial devices.

```
tCompositeEntry g_psDevices[2];
```

Once the array of devices has been allocated, this array is included in the USB composite device structure when the device structure is allocated and initialized. The code below shows this allocation:

```
//
// Initialize the USB composite device structure.
//
tUSBDCompositeDevice g_sCompDevice =
{
    //
    // TI USBLib VID.
    //
    USB_VID_TI_1CBE,

    //
    // PID for the composite serial device.
    //
    USB_PID_COMP_SERIAL,

    //
    // This is in 2mA increments so 500mA.
    //
    250,

    //
    // Bus powered device.
    //
    USB_CONF_ATTR_BUS_PWR,

    //
    // Generic USB handler for the composite device.
    //
    CompositeHandler,

    //
    // The string table.
    //
    g_pStringDescriptors,
    NUM_STRING_DESCRIPTORS,

    //
    // Include the array of composite devices.
    //
    NUM_DEVICES,
    g_psCompDevices
};
```

The last bit of memory that needs to be allocated is the USB composite device descriptor workspace which is provided at Initialization time. The allocation for two serial devices is shown below:

```
uint8_t pucDesciptorData[COMPOSITE_DCDC_SIZE*2];
```

Once all of the memory has been initialized and the appropriate memory allocated, the application must call the initialization functions for each device instance. In the case of the serial ports, the USB buffers used must also first be initialized before completing initialization.

```
//
// Initialize the transmit and receive buffers.
//
USBBufferInit((tUSBBuffer *)&g_sTxBufferA);
USBBufferInit((tUSBBuffer *)&g_sRxBufferA);
USBBufferInit((tUSBBuffer *)&g_sTxBufferB);
USBBufferInit((tUSBBuffer *)&g_sRxBufferB);

//
// Initialize the two serial port instances that are part of this composite
// device.
//
pvSerialDeviceA =
    USBDCDCCompositeInit(0, &g_sCDCDeviceA, &g_psCompDevices[0]);
pvSerialDeviceB =
    USBDCDCCompositeInit(0, &g_sCDCDeviceB, &g_psCompDevices[1]);

//
// Pass the device information to the USB library and place the device
// on the bus.
//
USBDCompositeInit(0, &g_sCompDevice, COMPOSITE_DCDC_SIZE*2,
                  pucDesciptorData);
```

When calling the USB device classes that are included with a composite device, the instance data for that class should be passed into the API. In the composite serial example that is being described in this section, the USB serial device classes provide the same callback function, ControlHandler(). The callback information for this was the device class structure which was specified as g_sCDCDeviceA or g_sCDCDeviceB for the serial devices. Since the device instance is different for each serial device, the application can simply cast the pointer to a pointer of type tUSBDCDCDevice and use the data directly as shown below and only access the requested device:

```
uint32_t
ControlHandler(void *pvCBData, uint32_t ui32Event,
               uint32_t ui32MsgValue, void *pvMsgData)
{
    tUSBDCDCDevice pCDCDevice;

    pCDCDevice = (tUSBDCDCDevice *)pvCBData;

    //
    // Which event are we being asked to process?
    //
    switch(ui32Event)
    {
        ...
```

```
    }
}
```

2.10 Composite Device Class Driver Definitions

Data Structures

- tUSBDCompositeDevice

Functions

- void * USBDCompositeInit (uint32_t ui32Index, tUSBDCompositeDevice *psDevice, uint32_t ui32Size, uint8_t *pui8Data)
- void USBDCompositeTerm (void *pvCompositeInstance)

2.10.1 Detailed Description

Definitions The macros and functions defined in this section can be found in header file `device/usbdcomp.h`.

2.10.2 Data Structure Documentation

2.10.2.1 tUSBDCompositeDevice

Definition:

```
typedef struct
{
    const uint16_t ui16VID;
    const uint16_t ui16PID;
    const uint16_t ui16MaxPowermA;
    const uint8_t ui8PwrAttributes;
    tUSBCallbackconst pfnCallback;
    const uint8_t *const *ppui8StringDescriptors;
    const uint32_t ui32NumStringDescriptors;
    const uint32_t ui32NumDevices;
    tCompositeEntry *const psDevices;
    tCompositeInstance sPrivateData;
}
tUSBDCompositeDevice
```

Members:

ui16VID The vendor ID that this device is to present in the device descriptor.

ui16PID The product ID that this device is to present in the device descriptor.

ui16MaxPowermA The maximum power consumption of the device, expressed in mA.

ui8PwrAttributes Indicates whether the device is self or bus-powered and whether or not it supports remote wake up. Valid values are USB_CONF_ATTR_SELF_PWR or USB_CONF_ATTR_BUS_PWR, optionally ORed with USB_CONF_ATTR_RWAKE.

pfnCallback A pointer to the callback function which will be called to notify the application of events relating to the operation of the composite device.

ppui8StringDescriptors A pointer to the string descriptor array for this device. This array must contain the following string descriptor pointers in this order. Language descriptor, Manufacturer name string (language 1), Product name string (language 1), Serial number string (language 1), Composite device interface description string (language 1), Configuration description string (language 1).
If supporting more than 1 language, the descriptor block (except for string descriptor 0) must be repeated for each language defined in the language descriptor.

ui32NumStringDescriptors The number of descriptors provided in the ppStringDescriptors array. This must be 1 + ((5 + (number of strings)) * (number of languages)).

ui32NumDevices The number of devices in the psDevices array.

psDevices This application supplied array holds the the top level device class information as well as the Instance data for that class.

sPrivateData The private data for this device instance. This memory must remain accessible for as long as the composite device is in use and must not be modified by any code outside the composite class driver.

Description:

The structure used by the application to define operating parameters for the composite device class.

2.10.3 Function Documentation

2.10.3.1 USBDCompositeInit

This function should be called once for the composite class device to initialize basic operation and prepare for enumeration.

Prototype:

```
void *
USBDCompositeInit(uint32_t ui32Index,
                  tUSBDCompositeDevice *psDevice,
                  uint32_t ui32Size,
                  uint8_t *pui8Data)
```

Parameters:

ui32Index is the index of the USB controller to initialize for composite device operation.

psDevice points to a structure containing parameters customizing the operation of the composite device.

ui32Size is the size in bytes of the data pointed to by the *pui8Data* parameter.

pui8Data is the data area that the composite class can use to build up descriptors.

Description:

In order for an application to initialize the USB composite device class, it must first call this function with the a valid composite device class structure in the *psDevice* parameter. This allows this function to initialize the USB controller and device code to be prepared to enumerate

and function as a USB composite device. The *ui32Size* and *pui8Data* parameters should be large enough to hold all of the class instances passed in via the *psDevice* structure. This is typically the full size of the configuration descriptor for a device minus its configuration header(9 bytes).

This function returns a void pointer that must be passed in to all other APIs used by the composite class.

See the documentation on the tUSBDCompositeDevice structure for more information on how to properly fill the structure members.

Returns:
This function returns 0 on failure or a non-zero void pointer on success.

2.10.3.2 USBDCompositeTerm

Shuts down the composite device.

Prototype:
```
void
USBDCompositeTerm(void *pvCompositeInstance)
```

Parameters:
pvCompositeInstance is the pointer to the device instance structure as returned by USBDCompositeInit().

Description:
This function terminates composite device interface for the instance not me supplied. Following this call, the *pvCompositeInstance* instance should not be used in any other calls.

Returns:
None.

2.11 Device Firmware Upgrade Device Class Driver

The DFU device class supports this runtime DFU capability, providing a simple method for an application to indicate to the host that it is DFU-capable and to be signalled that a USB-based firmware upgrade is being requested. The device class is unusual in that it must be used as part of a composite device. Runtime DFU capability makes no sense on its own since it is basically only an indication that the DFU USB boot loader is present and usable.

The USB boot loader must also be used by any device supporting the DFU runtime device class since it implements all DFU mode operation and performs the actual upgrade operation. The runtime device class adds two sections to the configuration descriptor for the main application - a DFU Interface Descriptor and a DFU Functional Descriptor. Standard DFU DETACH requests sent to the DFU interface from the host result in a callback being made to the client application indicating that it must transfer control back to the USB boot loader (via the `USBDDFUUpdateBegin()` function. This function removes the application's existing device from the USB bus then reenters the boot loader which, in turn, publishes DFU mode descriptors and reconnects to the bus as a pure DFU device capable of downloading or uploading application images from the host.

2.12 Device Firmware Upgrade Device Class Driver Definitions

Data Structures

- tUSBDDFUDevice

Defines

- COMPOSITE_DDFU_SIZE
- USBD_DFU_EVENT_DETACH

Functions

- void * USBDDFUCompositeInit (uint32_t ui32Index, tUSBDDFUDevice *psDFUDevice, tCompositeEntry *psCompEntry)
- void USBDDFUCompositeTerm (void *pvDFUInstance)
- void USBDDFUUpdateBegin (void)

2.12.1 Detailed Description

Definitions The macros and functions defined in this section can be found in header file `device/usbddfu\_rt.h`.

2.12.2 Data Structure Documentation

2.12.2.1 tUSBDDFUDevice

Definition:

```
typedef struct
{
    tUSBCallbackconst pfnCallback;
    void *const pvCBData;
    tDFUInstance sPrivateData;
}
tUSBDDFUDevice
```

Members:

pfnCallback A pointer to the callback function which will be called to notify the application of DETACH requests.

pvCBData A client-supplied pointer which will be sent as the first parameter in all calls made to the pfnCallback function.

sPrivateData The private instance data for this device class. This memory must remain accessible for as long as the DFU device is in use and must not be modified by any code outside the DFU class driver.

Description:

The structure used by the application to define operating parameters for the DFU device. Note that, unlike all other devices, this structure does not contain any fields which configure the device descriptor sent back to the host. The DFU runtime device class must be used as part of a composite device since all it provides is the capability to signal the device to switch into DFU mode in preparation for a firmware upgrade. Creating a device with nothing but DFU runtime mode capability is rather pointless so this is not supported.

2.12.3 Define Documentation

2.12.3.1 COMPOSITE_DDFU_SIZE

Definition:

```
#define COMPOSITE_DDFU_SIZE
```

Description:

The size of the memory that should be allocated to create a configuration descriptor for a single instance of the DFU runtime device. This does not include the configuration descriptor which is automatically ignored by the composite device class.

This label is used to compute the value which will be passed to the USBDCompositeInit function in the ui32Size parameter.

2.12.3.2 USBD_DFU_EVENT_DETACH

Definition:

```
#define USBD_DFU_EVENT_DETACH
```

Description:

This value is passed to the client via the callback function provided in the tUSBDDFUDevice structure and indicates that the host has sent a DETACH request to the DFU interface. This request indicates that the device detach from the USB bus and reattach in DFU mode in preparation for a firmware upgrade. Currently, this is the only event that the DFU runtime class reports to the client.

When this event is received, the client should call USBDDFUUpdateBegin() from a non-interrupt context at its earliest opportunity.

2.12.4 Function Documentation

2.12.4.1 USBDDFUCompositeInit

Initializes DFU device operation for a given USB controller.

Prototype:

```
void *
USBDDFUCompositeInit(uint32_t ui32Index,
                     tUSBDDFUDevice *psDFUDevice,
                     tCompositeEntry *psCompEntry)
```

Parameters:

ui32Index is the index of the USB controller which is to be initialized for DFU runtime device operation.

psDFUDevice points to a structure containing parameters customizing the operation of the DFU device.

psCompEntry is the composite device entry to initialize when creating a composite device.

Description:

The *psCompEntry* should point to the composite device entry to initialize. This is part of the array that is passed to the USBDCompositeInit() function.

Returns:

Returns zero on failure or a non-zero instance value that should be used with the remaining USB DFU APIs.

2.12.4.2 USBDDFUCompositeTerm

Shuts down the DFU device.

Prototype:

```
void
USBDDFUCompositeTerm(void *pvDFUInstance)
```

Parameters:

pvDFUInstance is the pointer to the device instance structure as returned by USBDDFUCompositeInit().

Description:

This function terminates DFU operation for the instance supplied and removes the device from the USB bus.

Following this call, the *pvDFUInstance* instance should not me used in any other calls.

Returns:

None.

2.12.4.3 USBDDFUUpdateBegin

Removes the current USB device from the bus and transfers control to the DFU boot loader.

Prototype:

```
void
USBDDFUUpdateBegin(void)
```

Description:

This function should be called from the application's main loop (i.e. not in interrupt context) following a callback to the USB DFU callback function notifying the application of a DETACH request from the host. The function will prepare the system to switch to DFU mode and transfer control to the boot loader in preparation for a firmware upgrade from the host.

The application must ensure that it has completed all necessary shutdown activities (saved any required data, etc.) before making this call since the function will not return.

Returns:

This function does not return.

2.13 HID Device Class Driver

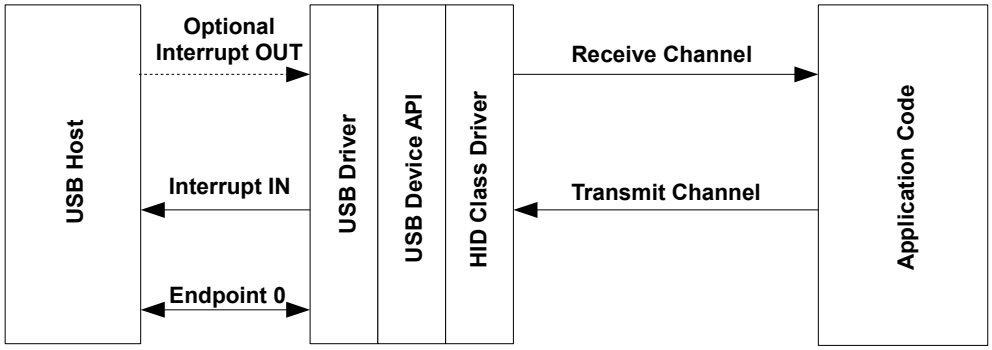
The USB Human Interface Class device class is an enormously versatile architecture for supporting a wide variety of input/output devices regardless of whether or not they actually deal with "Human Interfaces". Although typically thought of in the context of keyboards, mice and joysticks, the specification can cover practically any device offering user controls or data gathering capabilities.

Communication between the HID device and host is via a collection of "report" structures which are defined by the device in HID report descriptors which the host can query. Reports are defined both for communication of device input to the host and for output and feature selection from the host.

In addition to the flexibility offered by the basic architecture, HID devices also benefit from excellent operating system support for the class, meaning that no driver writing is necessary and, in the case of standard devices such as keyboards and joysticks, the device can connect to and operate with the host system without any new host software having to be written. Even in the case of a non-standard or vendor-specific HID device, the operating system support makes writing the host-side software very much more straightforward than developing the device using a vendor-specific class.

Despite these advantages, there is one downside to using HID. The interface is limited in the amount of data that can be transferred so is not suitable for use by devices which expect to use a high percentage of the USB bus bandwidth. Devices are limited to a maximum of 64KB of data per second for each report they support. Multiple reports can be used if necessary but high bandwidth devices may be better implemented using a class which supports bulk rather than interrupt endpoints (such as CDC or the generic bulk device class).

USB HID Device Model



This device class uses one or, optionally, two endpoints in addition to endpoint zero. One interrupt IN endpoint carries HID input reports from the device to the host. Output and Feature reports from the host to the device are typically carried via endpoint zero but devices which expect high host-to-device data rates can select to offer an independent interrupt OUT endpoint to carry these. Endpoint zero carries standard USB requests and also HID-specific descriptor requests.

The HID mouse and keyboard device APIs described later in this document are both implemented above the HID Device Class Driver API.

2.13.1 HID Device Class Events

The HID device class driver sends the following events to the application callback functions:

2.13.1.1 Receive Channel Events

- **USB_EVENT_CONNECTED**
- **USB_EVENT_DISCONNECTED**
- **USB_EVENT_RX_AVAILABLE**
- **USB_EVENT_ERROR**
- **USB_EVENT_SUSPEND**
- **USB_EVENT_RESUME**
- **USBD_HID_EVENT_IDLE_TIMEOUT**
- **USBD_HID_EVENT_GET_REPORT_BUFFER**
- **USBD_HID_EVENT_GET_REPORT**
- **USBD_HID_EVENT_SET_PROTOCOL**
- **USBD_HID_EVENT_GET_PROTOCOL**
- **USBD_HID_EVENT_SET_REPORT**
- **USBD_HID_EVENT_REPORT_SENT**

Note: The USB_EVENT_DISCONNECTED event will not be reported to the application if the MCU's PB1/USB0VBUS pin is connected to a fixed +5 Volts rather than directly to the VBUS pin on the USB connector or if the USB controller is configured to force device mode.

2.13.1.2 Transmit Channel Events

- **USB_EVENT_TX_COMPLETE**

2.13.2 Using the HID Device Class Driver

To add a USB HID interface to your application using the HID Device Class Driver, take the following steps.

- Add the following header files to the source file(s) which are to support USB:

```
#include "usb.h"
#include "include/usblib.h"
#include "include/usbhid.h"
#include "include/device/usbdevice.h"
#include "include/device/usbdhid.h"
```

- Define the string table which is used to describe various features of your new device to the host system. The following is the string table taken from the C28x Side `usb_ex2_dev_mouse` example application and CM Side `usb_ex2_device_mouse_cm` example application. Edit the actual strings to suit your application and take care to ensure that you also update the length field (the first byte) of each descriptor to correctly reflect the length of the string and descriptor header. The number of strings included will vary depending upon the device but must be at least 5. HID report descriptors may refer to string IDs and, if the descriptor for your device includes these, additional strings will be required. Also, if multiple languages are reported in string descriptor 0, you must ensure that you have strings available for each language with all language 1 strings occurring in order in a block before all language 2 strings and so on.

```
//*****************************************************************************
//
// The languages supported by this device.
//
//*****************************************************************************
const uint8_t g_pLangDescriptor[] =
{
    4,
    USB_DTYPE_STRING,
    USBShort(USB_LANG_EN_US)
};

//*****************************************************************************
//
// The manufacturer string.
//
//*****************************************************************************
const uint8_t g_pManufacturerString[] =
{
    (17 + 1) * 2,
    USB_DTYPE_STRING,
    'T', 0, 'e', 0, 'x', 0, 'a', 0, 's', 0, ' ', 0, 'I', 0, 'n', 0, 's', 0,
    't', 0, 'r', 0, 'u', 0, 'm', 0, 'e', 0, 'n', 0, 't', 0, 's', 0,
};

//*****************************************************************************
//
// The product string.
//
//*****************************************************************************
const uint8_t g_pProductString[] =
{
    (13 + 1) * 2,
    USB_DTYPE_STRING,
    'M', 0, 'o', 0, 'u', 0, 's', 0, 'e', 0, ' ', 0, 'E', 0, 'x', 0, 'a', 0,
    'm', 0, 'p', 0, 'l', 0, 'e', 0
};

//*****************************************************************************
//
// The serial number string.
```

```
//
//*****************************************************************************
const uint8_t g_pSerialNumberString[] =
{
    (8 + 1) * 2,
    USB_DTYPE_STRING,
    '1', 0, '2', 0, '3', 0, '4', 0, '5', 0, '6', 0, '7', 0, '8', 0
};

//*****************************************************************************
//
// The interface description string.
//
//*****************************************************************************
const uint8_t g_pHIDInterfaceString[] =
{
    (19 + 1) * 2,
    USB_DTYPE_STRING,
    'H', 0, 'I', 0, 'D', 0, ' ', 0, 'M', 0, 'o', 0, 'u', 0, 's', 0,
    'e', 0, ' ', 0, 'I', 0, 'n', 0, 't', 0, 'e', 0, 'r', 0, 'f', 0,
    'a', 0, 'c', 0, 'e', 0
};

//*****************************************************************************
//
// The configuration description string.
//
//*****************************************************************************
const uint8_t g_pConfigString[] =
{
    (23 + 1) * 2,
    USB_DTYPE_STRING,
    'H', 0, 'I', 0, 'D', 0, ' ', 0, 'M', 0, 'o', 0, 'u', 0, 's', 0,
    'e', 0, ' ', 0, 'C', 0, 'o', 0, 'n', 0, 'f', 0, 'i', 0, 'g', 0,
    'u', 0, 'r', 0, 'a', 0, 't', 0, 'i', 0, 'o', 0, 'n', 0
};

//*****************************************************************************
//
// The descriptor string table.
//
//*****************************************************************************
const uint8_t * const g_pStringDescriptors[] =
{
    g_pLangDescriptor,
    g_pManufacturerString,
    g_pProductString,
    g_pSerialNumberString,
    g_pHIDInterfaceString,
    g_pConfigString
};
```

```
#define NUM_STRING_DESCRIPTORS (sizeof(g_pStringDescriptors)                  /
                                sizeof(uint8_t *))
```

- Develop the HID report descriptors and, if required, physical descriptors for your device and, from these, the HID descriptor itself. Details of how to do this are beyond the scope of this document other than to say that macros in header file `usbdhid.h` are included to help add the various tags required in the descriptor. For information on how these descriptors are constructed, please see the "USB Device Class Definition for Human Interface Devices, version 1.11" which can be downloaded from http://www.usb.org/developers/devclass_docs/HID1_11.pdf. The required structures for a BIOS-compatible HID mouse are:

```
//*****************************************************************************
//
// The report descriptor for the BIOS mouse class device.
//
//*****************************************************************************
static const uint8_t g_pui8ucMouseReportDescriptor[]=
{
    UsagePage(USB_HID_GENERIC_DESKTOP),
    Usage(USB_HID_MOUSE),
    Collection(USB_HID_APPLICATION),
        Usage(USB_HID_POINTER),
        Collection(USB_HID_PHYSICAL),

            //
            // The buttons.
            //
            UsagePage(USB_HID_BUTTONS),
            UsageMinimum(1),
            UsageMaximum(3),
            LogicalMinimum(0),
            LogicalMaximum(1),

            //
            // 3 - 1 bit values for the buttons.
            //
            ReportSize(1),
            ReportCount(3),
            Input(USB_HID_INPUT_DATA | USB_HID_INPUT_VARIABLE |
                  USB_HID_INPUT_ABS),

            //
            // 1 - 5 bit unused constant value to fill the 8 bits.
            //
            ReportSize(5),
            ReportCount(1),
            Input(USB_HID_INPUT_CONSTANT | USB_HID_INPUT_ARRAY |
                  USB_HID_INPUT_ABS),

            //
            // The X and Y axis.
            //
            UsagePage(USB_HID_GENERIC_DESKTOP),
```

```
            Usage(USB_HID_X),
            Usage(USB_HID_Y),
            LogicalMinimum(-127),
            LogicalMaximum(127),

            //
            // 2 - 8 bit Values for x and y.
            //
            ReportSize(8),
            ReportCount(2),
            Input(USB_HID_INPUT_DATA | USB_HID_INPUT_VARIABLE |
                  USB_HID_INPUT_RELATIVE),
        EndCollection,
    EndCollection,
};

//*****************************************************************************
//
// The HID class descriptor table. For the mouse class, we have only a single
// report descriptor.
//
//*****************************************************************************
static const uint8_t * const g_pMouseClassDescriptors[] =
{
    g_pucMouseReportDescriptor
};

//*****************************************************************************
//
// The HID descriptor for the mouse device.
//
//*****************************************************************************
tHIDDescriptor g_sMouseHIDDescriptor =
{
     USB_VID_TI_1CBE,                  // bLength
     USB_PID_MOUSE,                    // bDescriptorType
     500,                              // Power Consumption
     USB_CONF_ATTR_SELF_PWR,           // Power Attribute
     MouseHandler,                     // Handler
         (void *)&g_sMouseDevice,          // Mouse Callback
     g_pStringDescriptors,             // String descriptor
     NUM_STRING_DESCRIPTORS // Size of report descriptor
};
```

- Define an array of *tHIDReportIdle* structures in RAM with one entry for each input report your device supports. Initialize the `ucDuration4mS` and *ucReportID* fields in each of the entries to set the default idle report time for each input report. Note that *ucDuration4mS* defines the idle time in 4mS increments as used in the USB HID Set_Idle and Get_Idle requests. The times defined in these structures are used to determine how often a given input report is resent to the host in the absence of any device state change. For example, a device supporting two input reports with IDs 1 and 2 may initialize the array as follows:

```
tHIDReportIdle g_psReportIdle[2] =
```

```
{
    { 125, 1, 0, 0 }, // Report 1 polled every 500mS (4 * 125).
    {   0, 2, 0, 0}   // Report 2 is not polled (0mS timeout)
};
```

- Define a *tUSBDHIDDevice* structure and initialize all fields as required for your application. The following example shows a structure suitable for a BIOS-compatible mouse device which publishes a single input report.

```
const tUSBDHIDDevice g_sHIDMouseDevice =
{
    //
    // The Vendor ID you have been assigned by USB-IF.
    //
    USB_VID_YOUR_VENDOR_ID,

    //
    // The product ID you have assigned for this device.
    //
    USB_PID_YOUR_PRODUCT_ID,

    //
    // The power consumption of your device in milliamps.
    //
    POWER_CONSUMPTION_MA,

    //
    // The value to be passed to the host in the USB configuration descriptor's
    // bmAttributes field.
    //
    USB_CONF_ATTR_BUS_PWR,

    //
    // This mouse supports the boot subclass.
    //
    USB_HID_SCLASS_BOOT,

    //
    // This device supports the BIOS mouse report protocol.
    //
    USB_HID_PROTOCOL_MOUSE,

    //
    // The device has a single input report.
    //
    1,

    //
    // A pointer to our array of tHIDReportIdle structures. For this device,
    // the array must have 1 element (matching the value of the previous field)
    //
    g_psMouseReportIdle,
```

```
    //
    // A pointer to your receive callback event handler.
    //
    YourUSBReceiveEventCallback,

    //
    // A value that you want passed to the receive callback alongside every
    // event.
    //
    (void *)&g_sYourInstanceData,

    //
    // A pointer to your transmit callback event handler.
    //
    YourUSBTransmitEventCallback,

    //
    // A value that you want passed to the transmit callback alongside every
    // event.
    //
    (void *)&g_sYourInstanceData,

    //
    // This device does not want to use a dedicated interrupt OUT endpoint
    // since there are no output or feature reports required.
    //
    false,

    //
    // A pointer to the HID descriptor for the device.
    //
    &g_sMouseHIDDescriptor,

    //
    // A pointer to the array of HID class descriptor pointers for this device.
    // The number of elements in this array and their order must match the
    // information in the HID descriptor provided above.
    //
    g_pMouseClassDescriptors,

    //
    // A pointer to your string table.
    //
    g_pStringDescriptors,

    //
    // The number of entries in your string table. This must equal
    // (1 + (5 + (num HID strings)) * (num languages)).
    //
    NUM_STRING_DESCRIPTORS
};
```

- Add a receive event handler function, YourUSBReceiveEventCallback in the previous example,

to your application taking care to handle all messages which require a particular response. For the HID device class the following receive callback events MUST be handled by the application:

- **USB_EVENT_RX_AVAILABLE**
- **USBD_HID_EVENT_IDLE_TIMEOUT**
- **USBD_HID_EVENT_GET_REPORT_BUFFER**
- **USBD_HID_EVENT_GET_REPORT**
- **USBD_HID_EVENT_SET_PROTOCOL** (for BIOS protocol devices)
- **USBD_HID_EVENT_GET_PROTOCOL** (for BIOS protocol devices)
- **USBD_HID_EVENT_SET_REPORT**

Although no other events must be handled, **USB_EVENT_CONNECTED** and **USB_EVENT_DISCONNECTED** will typically be required since these indicate when a host connects or disconnects and allow the application to flush any buffers or reset state as required. Attempts to send data when the host is disconnected will fail.

- Add a transmit event handler function, YourUSBTransmitEventCallback in the previous example, to your application and use **USB_EVENT_TX_COMPLETE** to indicate when a new report may be scheduled for transmission. While a report is being transmitted, attempts to send another report via USBDHIDReportWrite() will fail.
- From your main initialization function call the HID device class driver initialization function to configure the USB controller and place the device on the bus.

```
pvDevice = USBDHIDMouseInit(0, &g_sHIDMouseDevice);
```

- Assuming *pvDevice* returned is not NULL, your device is now ready to communicate with a USB host.
- Once the host connects, your control event handler will be sent `USB_EVENT_CONNECTED` and the first input report may be sent to the host using USBDHIDReportWrite() with following packets transmitted as soon as **USB_EVENT_TX_COMPLETE** is received via the transmit event handler.

2.13.3 Using the Composite HID Mouse Device Class

When using the HID mouse device class in a composite device, the configuration of the device is very similar to how it is configured as a non-composite device. Follow all of the configuration steps in the previous section with the exception of calling USBDHIDMouseCompositeInit() instead of USBDHIDMouseInit(). This will prepare an instance of the HID mouse device class to be enumerated as part of a composite device. The USBDHIDMouseCompositeInit() function takes the mouse device structure and a pointer to a tCompositeEntry value so that it can properly initialize the mouse device and the composite entry that will later be passed to the USBDCompositeInit() function. The code example below provides an example of how to initialize a mouse device to be a part of a composite device.

```
//
// These should be initialized with valid values for each class.
//
extern tUSBDHIDMouseDevice g_sHIDMouseDevice;

tCompositeEntry psCompEntries[2];
```

Input reports are sent from the device to the host in response to device state changes, queries from the host or a configurable timeout. In the case of a state change, the device sends a new copy of the relevant input report to the host via the interrupt IN endpoint. This is accomplished by calling USBDHIDReportWrite(). Whereas other USB device class drivers require that the application send no more than 1 packet of data in each call to the driver's "PacketWrite" function, the HID device class driver allows a complete report to be sent. If the report passed is longer than the maximum packet size for the endpoint, the class driver handles the process of breaking it up into multiple USB packets. Once a full report has been transmitted to the host and acknowledged, the application's transmit event handler receives **USB_EVENT_TX_COMPLETE** indicating that the application is free to send another report.

The host may also poll for the latest version of an input report. This procedure involves a request on endpoint zero and results in a sequence of events that the application must respond to. On receipt of the Get_Report request, the HID device class driver sends **USBD_HID_EVENT_GET_REPORT** to the application receive callback. The application must respond to this by returning a pointer to the latest version of the requested report and the size of the report in bytes. This data is then returned to the host via endpoint zero and successful completion of the transmission is notified to the application using **USBD_HID_EVENT_REPORT_SENT** passed to the receive callback.

One other condition may cause an input report to be sent. Each input report has a timeout associated with it and, when this time interval expires, the report must be returned to the host regardless of whether or not the device state has changed. The timeout is set using a Set_Idle request from the host and may be completely disabled (as is typically done for mice and keyboards when communicating with a Windows PC, for example) by setting the timeout to 0.

The HID device class driver internally tracks the required timeouts for each input report. When a timer expires, indicating that the report must be resent, **USBD_HID_EVENT_IDLE_TIMEOUT** is sent to the application receive callback. As in the previous case, the application must respond with a pointer to the appropriate report and its length in bytes. In this case, the returned report is transmitted to the host using the interrupt IN endpoint and the successful completion of the transmission is notified to the application using **USB_EVENT_TX_COMPLETE** sent to the transmit callback. Note that the application returns information on the location and size of the report and MUST NOT call USBDHIDReportWrite() in response to this event.

Output and Feature reports are sent from the host to the device to instruct it to set various parameters and options. A device can chose whether all host-to-device report communication takes place via endpoint zero or whether a dedicated interrupt OUT endpoint is used. Typically host-to-device traffic is low bandwidth and endpoint zero communication can be used but, if a dedicated endpoint is required, the field *bUseOutEndpoint* in the *tUSBDHIDDevice* structure for the device should be set to **true**.

If using a dedicated endpoint for output and feature reports, the application receive callback will be called with **USB_EVENT_RX_AVAILABLE** whenever a report packet is available. During this callback, the application can call USBDHIDPacketRead() to retrieve the packet. If it is not possible to read the packet immediately, the HID device class driver will call the application back later to give it another opportunity. Until the packet is read, NAK will be sent to the host preventing more data from being sent.

In the more typical case where endpoint zero is used to transfer output and feature reports, the application can expect the following sequence of events on the receive callback.

- **USBD_HID_EVENT_GET_REPORT_BUFFER** indicates that a Set_Report request has been received from the host and the device class driver is requesting a buffer into which the received report can be written. The application must return a pointer to a buffer which is at least as large as required to store the report.

- **USBD_HID_EVENT_SET_REPORT** follows next once the report data has been read from endpoint zero into the buffer supplied on the earlier **USBD_HID_EVENT_GET_REPORT_BUFFER** callback. The device class driver will not access the report buffer after this event is sent and the application may handle the memory as it wishes following this point.

2.14 HID Device Class Driver Definitions

Data Structures

- tHIDClassDescriptorInfo
- tHIDDescriptor
- tHIDKeyboardUsageTable
- tHIDReportIdle
- tUSBDHIDDevice

Defines

- Collection(ui8Value)
- COMPOSITE_DHID_SIZE
- EndCollection
- Feature(ui8Value)
- Feature2(ui16Value)
- Input(ui8Value)
- Input2(ui16Value)
- LogicalMaximum(i8Value)
- LogicalMinimum(i8Value)
- Output(ui8Value)
- Output2(ui16Value)
- PhysicalMaximum(i16Value)
- PhysicalMinimum(i16Value)
- ReportCount(ui8Value)
- ReportID(ui8Value)
- ReportSize(ui8Value)
- Unit(ui32Value)
- UnitAccelerationSI
- UnitAngAccelerationSI
- UnitCurrent_A
- UnitDistance_cm
- UnitDistance_i
- UnitEnergySI
- UnitExponent(i8Value)
- UnitForceSI
- UnitMass_g

- UnitMomentumSI
- UnitRotation_deg
- UnitRotation_rad
- UnitTemp_F
- UnitTemp_K
- UnitTime_s
- UnitVelocitySI
- UnitVoltage
- Usage(ui8Value)
- UsageMaximum(ui8Value)
- UsageMinimum(ui8Value)
- UsagePage(ui8Value)
- UsagePageVendor(ui16Value)
- UsageVendor(ui16Value)
- USBD_HID_EVENT_GET_PROTOCOL
- USBD_HID_EVENT_GET_REPORT
- USBD_HID_EVENT_GET_REPORT_BUFFER
- USBD_HID_EVENT_IDLE_TIMEOUT
- USBD_HID_EVENT_REPORT_SENT
- USBD_HID_EVENT_SET_PROTOCOL
- USBD_HID_EVENT_SET_REPORT

Functions

- void * USBDHIDCompositeInit (uint32_t ui32Index, tUSBDHIDDevice *psHIDDevice, tCompositeEntry *psCompEntry)
- void * USBDHIDInit (uint32_t ui32Index, tUSBDHIDDevice *psHIDDevice)
- uint32_t USBDHIDPacketRead (void *pvHIDInstance, uint8_t *pi8Data, uint32_t ui32Length, bool bLast)
- void USBDHIDPowerStatusSet (void *pvHIDInstance, uint8_t ui8Power)
- bool USBDHIDRemoteWakeupRequest (void *pvHIDInstance)
- uint32_t USBDHIDReportWrite (void *pvHIDInstance, uint8_t *pi8Data, uint32_t ui32Length, bool bLast)
- uint32_t USBDHIDRxPacketAvailable (void *pvHIDInstance)
- void * USBDHIDSetRxCBData (void *pvHIDInstance, void *pvCBData)
- void * USBDHIDSetTxCBData (void *pvHIDInstance, void *pvCBData)
- void USBDHIDTerm (void *pvHIDInstance)
- uint32_t USBDHIDTxPacketAvailable (void *pvHIDInstance)

2.14.1 Detailed Description

The macros and functions defined in this section can be found in header file `device/usbdhid.h`. Users of the HID device class driver will also need to include `usbhid.h` which includes HID-related definitions required by both host and device implementations.

2.14.2 Data Structure Documentation

2.14.2.1 tHIDClassDescriptorInfo

Definition:

```
typedef struct
{
    uint8_t bDescriptorType;
    uint16_t wDescriptorLength;
}
tHIDClassDescriptorInfo
```

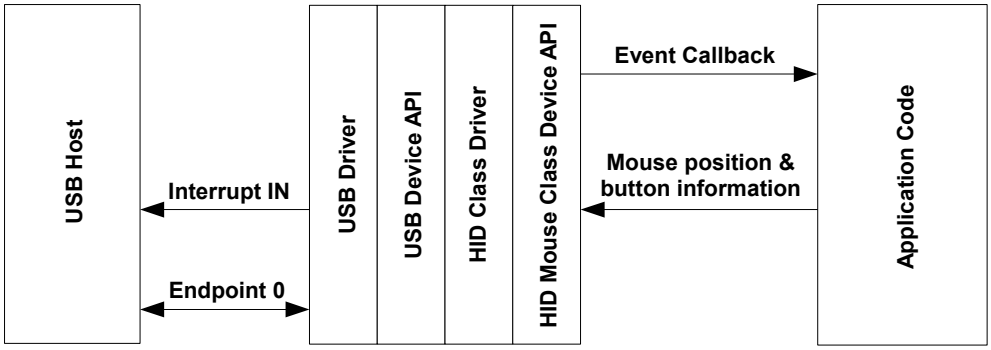
Members:

bDescriptorType

2.15 HID Mouse Device Class API

The USB HID device class is extremely versatile but somewhat daunting. For applications which want to offer a mouse-like appearance to a USB host, however, the HID Mouse Device Class API may be used without the need to develop any HID-specific software. This high-level interface completely encapsulates the USB stack and USB HID device class driver and allows an application to simply instantiate a USB mouse device and call a single function to notify the USB host of mouse movement and button presses.
The USB mouse device uses the BIOS mouse subclass and protocol so is recognized by the vast majority of host operating systems and BIOSs without the need for additional host-side software. The mouse provides two axis movement (reported to the host in terms of relative position changes) and up to three buttons which may be either pressed or released.

USB HID Mouse Device Model



The `usb_ex2_dev_mouse` C28x example application and `usb_ex2_dev_mouse_cm` CM example application makes use of this device class API.

2.15.1 HID Mouse Device API Events

The HID mouse device API sends the following events to the application callback function:

- **USB_EVENT_CONNECTED**

- **USB_EVENT_DISCONNECTED**
- **USB_EVENT_TX_COMPLETE**
- **USB_EVENT_ERROR**
- **USB_EVENT_SUSPEND**
- **USB_EVENT_RESUME**

Note: The **USB_EVENT_DISCONNECTED** event will not be reported to the application if the MCU's PB1/USB0VBUS pin is connected to a fixed +5 Volts rather than directly to the VBUS pin on the USB connector or if the USB controller is configured to force device mode.

2.15.2 Using the HID Mouse Device Class API

To add a USB HID mouse interface to your application using the HID Mouse Device Class API, take the following steps.

- Add the following header files to the source file(s) which are to support USB:

```
#include "usb.h"
#include "include/usblib.h"
#include "include/device/usbdhidmouse.h"
```

- Define the string table which is used to describe various features of your new device to the host system. An example of a suitable string table for a mouse device can be found in Using the HID Device Class Driver. This table must include a minimum of 6 entries - string descriptor 0 defining the language(s) available and 5 strings for each supported language.
- Define a *tUSBDHIDMouseDevice* structure and initialize all fields as required for your application.

```
const tUSBDHIDMouseDevice g_sMouseDevice =
{
    //
    // The Vendor ID you have been assigned by USB-IF.
    //
    USB_VID_YOUR_VENDOR_ID,

    //
    // The product ID you have assigned for this device.
    //
    USB_PID_YOUR_PRODUCT_ID,

    //
    // The power consumption of your device in milliamps.
    //
    POWER_CONSUMPTION_MA,

    //
    // The value to be passed to the host in the USB configuration descrip
    // bmAttributes field.
    //
    USB_CONF_ATTR_SELF_PWR,

    //
    // A pointer to your mouse callback event handler.
```

```
    //
    YourMouseHandler,

    //
    // A value that you want passed to the callback alongside every event.
    //
    (void *)&g_sYourInstanceData,

    //
    // A pointer to your string table.
    //
    g_pStringDescriptors,

    //
    // The number of entries in your string table. This must equal
    // (1 + (5 * (num languages))).
    //
    NUM_STRING_DESCRIPTORS
};
```

- Add a mouse event handler function, YourMouseHandler in the previous example, to your application. A minimal implementation can ignore all events though **USB_EVENT_TX_COMPLETE** can be used to ensure that mouse messages are not sent when a previous report is still in transit to the host. Attempts to send a new mouse report when the previous report has not yet been acknowledged will result in return code **MOUSE_ERR_TX_ERROR** from USBDHIDMouseStateChange().
- From your main initialization function call the HID mouse device API initialization function to configure the USB controller and place the device on the bus.

```
pvDevice = USBDHIDMouseInit(0, &g_sMouseDevice);
```

- Assuming *pvDevice* returned is not NULL, your mouse device is now ready to communicate with a USB host.
- Once the host connects, your mouse event handler will be sent **USB_EVENT_CONNECTED** after which calls can be made to USBDHIDMouseStateChange()to inform the host of mouse position and button state changes.

2.16 HID Mouse Device Class API Definitions

Data Structures

- struct tUSBDHIDMouseDevice

Defines

- #define MOUSE_ERR_NOT_CONFIGURED
- #define MOUSE_ERR_TX_ERROR
- #define MOUSE_REPORT_BUTTON_1
- #define MOUSE_REPORT_BUTTON_2
- #define MOUSE_REPORT_BUTTON_3
- #define MOUSE_SUCCESS

Functions

- void * USBDHIDMouseCompositeInit (uint32_t ui32Index, tUSBDHIDMouseDevice *psMouseDevice, tCompositeEntry *psCompEntry)
- void * USBDHIDMouseInit (uint32_t ui32Index, tUSBDHIDMouseDevice *psMouseDevice)
- void USBDHIDMousePowerStatusSet (void *pvMouseDevice, uint8_t ui8Power)
- bool USBDHIDMouseRemoteWakeupRequest (void *pvMouseDevice)
- void * USBDHIDMouseSetCBData (void *pvMouseDevice, void *pvCBData)
- uint32_t USBDHIDMouseStateChange (void *pvMouseDevice, int8_t i8DeltaX, int8_t i8DeltaY, uint8_t ui8Buttons)
- void USBDHIDMouseTerm (void *pvMouseDevice)

2.16.1 Detailed Description

The macros and functions defined in this section can be found in header file `device/usbdhidmouse.h`.

2.16.2 Define Documentation

2.16.2.1 #define MOUSE_ERR_NOT_CONFIGURED

USBDHIDMouseStateChange returns this value if it is called before the USB host has connected and configured the device. All mouse state information passed on the call is been ignored.

2.16.2.2 #define MOUSE_ERR_TX_ERROR

This return code from USBDHIDMouseStateChange indicates that an error was reported while attempting to send a report to the host. A client should assume that the host has disconnected if this return code is seen.

2.16.2.3 #define MOUSE_REPORT_BUTTON_1

Setting this bit in the ui8Buttons parameter to USBDHIDMouseStateChange indicates to the USB host that button 1 on the mouse is pressed.

2.16.2.4 #define MOUSE_REPORT_BUTTON_2

Setting this bit in the ui8Buttons parameter to USBDHIDMouseStateChange indicates to the USB host that button 2 on the mouse is pressed.

2.16.2.5 #define MOUSE_REPORT_BUTTON_3

Setting this bit in the ui8Buttons parameter to USBDHIDMouseStateChange indicates to the USB host that button 3 on the mouse is pressed.

2.16.2.6 #define MOUSE_SUCCESS

This return code from USBDHIDMouseStateChange indicates success.

2.16.3 Function Documentation

2.16.3.1 void * USBDHIDMouseCompositeInit (uint32_t *ui32Index*, tUSBDHIDMouseDevice * *psMouseDevice*, tCompositeEntry * *psCompEntry*)

Initializes HID mouse device operation for a given USB controller.

Parameters:

ui32Index is the index of the USB controller which is to be initialized for HID mouse device operation.

psMouseDevice points to a structure containing parameters customizing the operation of the HID mouse device.

psCompEntry is the composite device entry to initialize when creating a composite device.

This call is very similar to USBDHIDMouseInit() except that it is used for initializing an instance of the HID mouse device for use in a composite device. If this HID mouse is part of a composite device, then the *psCompEntry* should point to the composite device entry to initialize. This is part of the array that is passed to the USBDCompositeInit() function.

Returns:

Returns zero on failure or a non-zero instance value that should be used with the remaining USB HID Mouse APIs.

2.16.3.2 void * USBDHIDMouseInit (uint32_t *ui32Index*, tUSBDHIDMouseDevice * *psMouseDevice*)

Initializes HID mouse device operation for a given USB controller.

Parameters:

ui32Index is the index of the USB controller which is to be initialized for HID mouse device operation.

psMouseDevice points to a structure containing parameters customizing the operation of the HID mouse device.

An application wishing to offer a USB HID mouse interface to a USB host must call this function to initialize the USB controller and attach the mouse device to the USB bus. This function performs all required USB initialization.

On successful completion, this function returns the *psMouseDevice* pointer passed to it. This must be passed on all future calls to the HID mouse device driver.

When a host connects and configures the device, the application callback receives **USB_EVENT_CONNECTED** after which calls can be made to USBDHIDMouseStateChange() to report pointer movement and button presses to the host.

Note:

The application must not make any calls to the lower level USB device interfaces if interacting with USB via the USB HID mouse device API. Doing so causes unpredictable (though almost certainly unpleasant) behavior.

Returns:

Returns NULL on failure or the psMouseDevice pointer on success.

2.16.3.3 void USBDHIDMousePowerStatusSet (void * *pvMouseDevice*, uint8_t *ui8Power*)

Reports the device power status (bus- or self-powered) to the USB library.

Parameters:

pvMouseDevice is the pointer to the mouse device instance structure.

ui8Power indicates the current power status, either **USB_STATUS_SELF_PWR** or **USB_STATUS_BUS_PWR**.

Applications which support switching between bus- or self-powered operation should call this function whenever the power source changes to indicate the current power status to the USB library. This information is required by the USB library to allow correct responses to be provided when the host requests status from the device.

Returns:

None.

2.16.3.4 bool USBDHIDMouseRemoteWakeupRequest (void * *pvMouseDevice*)

Requests a remote wake up to resume communication when in suspended state.

Parameters:

pvMouseDevice is the pointer to the mouse device instance structure.

When the bus is suspended, an application which supports remote wake up (advertised to the host via the configuration descriptor) may call this function to initiate remote wake up signaling to the host. If the remote wake up feature has not been disabled by the host, this causes the bus to resume operation within 20mS. If the host has disabled remote wake up, **false** is returned to indicate that the wake up request was not successful.

Returns:

Returns **true** if the remote wake up is not disabled and the signaling was started or **false** if remote wake up is disabled or if signaling is currently ongoing following a previous call to this function.

2.16.3.5 void * USBDHIDMouseSetCBData (void * *pvMouseDevice*, void * *pvCBData*)

Sets the client-specific pointer parameter for the mouse callback.

Parameters:

pvMouseDevice is the pointer to the mouse device instance structure.

pvCBData is the pointer that client wishes to be provided on each event sent to the mouse callback function.

The client uses this function to change the callback pointer passed in the first parameter on all callbacks to the *pfnCallback* function passed on USBDHIDMouseInit().
If a client wants to make runtime changes in the callback pointer, it must ensure that the pvMouseDevice structure passed to USBDHIDMouseInit() resides in RAM. If this structure is in flash, callback data changes are not possible.

Returns:

Returns the previous callback pointer that was set for this instance.

2.16.3.6 uint32_t USBDHIDMouseStateChange (void * *pvMouseDevice*, int8_t *i8DeltaX*, int8_t *i8DeltaY*, uint8_t *ui8Buttons*)

Reports a mouse state change, pointer movement or button press, to the USB host.

Parameters:

pvMouseDevice is the pointer to the mouse device instance structure.

i8DeltaX is the relative horizontal pointer movement that the application wishes to report. Valid values are in the range [-127, 127] with positive values indicating movement to the right.

i8DeltaY is the relative vertical pointer movement that the application wishes to report. Valid values are in the range [-127, 127] with positive values indicating downward movement.

ui8Buttons is a bit mask indicating which (if any) of the three mouse buttons is pressed. Valid values are logical OR combinations of **MOUSE_REPORT_BUTTON_1**, **MOUSE_REPORT_BUTTON_2** and **MOUSE_REPORT_BUTTON_3**.

This function is called to report changes in the mouse state to the USB host. These changes can be movement of the pointer, reported relative to its previous position, or changes in the states of up to 3 buttons that the mouse may support. The return code indicates whether or not the mouse report could be sent to the host. In cases where a previous report is still being transmitted, **MOUSE_ERR_TX_ERROR** is returned and the state change is ignored.

Returns:

Returns **MOUSE_SUCCESS** on success, **MOUSE_ERR_TX_ERROR** if an error occurred while attempting to schedule transmission of the mouse report to the host (typically due to a previous report which has not yet completed transmission or due to disconnection of the host) or **MOUSE_ERR_NOT_CONFIGURED** if called before a host has connected to and configured the device.

2.16.3.7 void USBDHIDMouseTerm (void * *pvMouseDevice*)

Shuts down the HID mouse device.

Parameters:

pvMouseDevice is the pointer to the device instance structure.

This function terminates HID mouse operation for the instance supplied and removes the device from the USB bus. Following this call, the *pvMouseDevice* instance may not me used in any other call to the HID mouse device other than USBDHIDMouseInit().

Returns:

None.

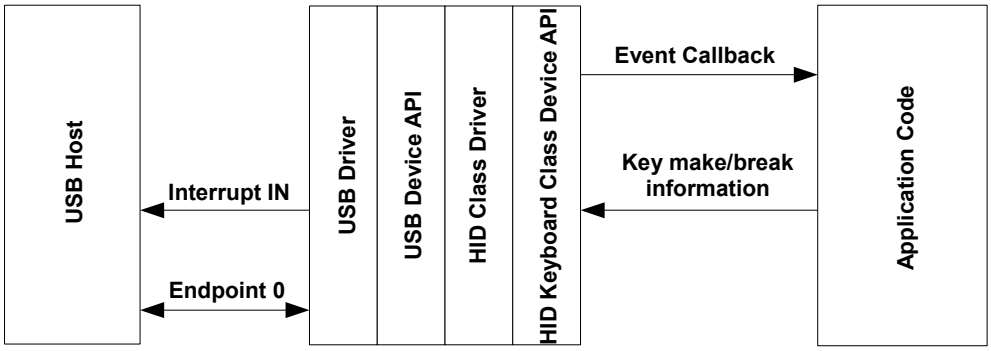
2.17 HID Keyboard Device Class API

As with the HID Mouse Device Class API described above, the HID Keyboard Device Class API provides an easy-to-use high-level interface for applications wishing to appear to the USB host as a BIOS-compatible keyboard. The keyboard supports up to 6 simultaneously pressed, non-modifier keys and up to 5 state indication LEDs.

Key press and release notifications along with the state of the modifier keys (Shift, Ctrl, Alt, etc.) are passed to the API in a single API call and a callback informs the application whenever the host requests that the LED states be changed.

Keys are identified to the API by means of USB HID key usage codes. A subset of these are defined in the header file `usbhid.h` and the full set can be found in the document "Universal Serial Bus (USB) HID Usage Tables" which can be downloaded from http://www.usb.org/developers/devclass_docs/Hut1_12.pdf.

USB HID Keyboard Device Model



The `usb_dev_keyboard` example application makes use of this device class API.

2.17.1 HID Keyboard Device API Events

The HID keyboard device API sends the following events to the application callback function:

- **USB_EVENT_CONNECTED**
- **USB_EVENT_DISCONNECTED**
- **USB_EVENT_TX_COMPLETE**
- **USB_EVENT_ERROR**
- **USB_EVENT_SUSPEND**
- **USB_EVENT_RESUME**
- **USBD_HID_KEYB_EVENT_SET_LEDS**

Note: The **USB_EVENT_DISCONNECTED** event will not be reported to the application if the MCU's PB1/USB0VBUS pin is connected to a fixed +5 Volts rather than directly to the VBUS pin on the USB connector or if the USB controller is configured to force device mode.

- Add the following header files to the source file(s) which are to support USB:

```
#include "usb.h"
#include "include/usblib.h"
#include "include/device/usbdhidkeyb.h"
```

- Define the string table which is used to describe various features of your new device to the host system. The string table found in Using the HID Device Class Driver illustrates the format required. This table must include a minimum of 6 entries - string descriptor 0 defining the language(s) available and 5 strings for each supported language.
- Define a *tUSBDHIDKeyboardDevice* structure and initialize all fields as required for your application.

```
const tUSBDHIDKeyboardDevice g_sKeyboardDevice =
{
    //
    // The Vendor ID you have been assigned by USB-IF.
```

```
    //
    USB_VID_YOUR_VENDOR_ID,

    //
    // The product ID you have assigned for this device.
    //
    USB_PID_YOUR_PRODUCT_ID,

    //
    // The power consumption of your device in milliamps.
    //
    POWER_CONSUMPTION_MA,

    //
    // The value to be passed to the host in the USB configuration descrip
    // bmAttributes field.
    //
    USB_CONF_ATTR_SELF_PWR,

    //
    // A pointer to your keyboard callback event handler.
    //
    YourKeyboardHandler,

    //
    // A value that you want passed to the callback alongside every event.
    //
    (void *)&g_sYourInstanceData,

    //
    // A pointer to your string table.
    //
    g_pStringDescriptors,

    //
    // The number of entries in your string table. This must equal
    // (1 + (5 * (num languages))).
    //
    NUM_STRING_DESCRIPTORS
};
```

- Add a keyboard event handler function, YourKeyboardHandler in the previous example, to your application. A minimal implementation can ignore all events since key information is buffered in the API and sent later if USBDHIDKeyboardKeyStateChange() is called while a previous report transmission remains unacknowledged.
- From your main initialization function call the HID keyboard device API initialization function to configure the USB controller and place the device on the bus.

```
pvDevice = USBDHIDKeyboardInit(0, &g_sKeyboardDevice);
```

- Assuming *pvDevice* returned is not NULL, your keyboard device is now ready to communicate with a USB host.
- Once the host connects, your keyboard event handler will be sent **USB_EVENT_CONNECTED** after which calls can be made to USBDHIDKeyboardKeyStateChange()to inform the host of key press and release events.

2.18 HID Keyboard Device Class API Definitions

Data Structures

- struct tUSBDHIDKeyboardDevice

Defines

- #define KEYB_ERR_NOT_CONFIGURED
- #define KEYB_ERR_NOT_FOUND
- #define KEYB_ERR_TOO_MANY_KEYS
- #define KEYB_ERR_TX_ERROR
- #define KEYB_MAX_CHARS_PER_REPORT
- #define KEYB_SUCCESS
- #define USBD_HID_KEYB_EVENT_SET_LEDS

Functions

- void * USBDHIDKeyboardCompositeInit (uint32_t ui32Index, tUSBDHIDKeyboardDevice *psHIDKbDevice, tCompositeEntry *psCompEntry)
- void * USBDHIDKeyboardInit (uint32_t ui32Index, tUSBDHIDKeyboardDevice *psHIDKbDevice)
- uint32_t USBDHIDKeyboardKeyStateChange (void *pvKeyboardDevice, uint8_t ui8Modifiers, uint8_t ui8UsageCode, bool bPress)
- void USBDHIDKeyboardPowerStatusSet (void *pvKeyboardDevice, uint8_t ui8Power)
- bool USBDHIDKeyboardRemoteWakeupRequest (void *pvKeyboardDevice)
- void * USBDHIDKeyboardSetCBData (void *pvKeyboardDevice, void *pvCBData)
- void USBDHIDKeyboardTerm (void *pvKeyboardDevice)

2.18.1 Detailed Description

The macros and functions defined in this section can be found in header file `device/usbdhidkeyb.h`.

2.18.2 Define Documentation

2.18.2.1 #define KEYB_ERR_NOT_CONFIGURED

USBDHIDKeyboardKeyStateChange returns this value if it is called before the USB host has connected and configured the device. Any key usage code passed will be stored and passed to the host once configuration completes.

2.18.2.2 #define KEYB_ERR_NOT_FOUND

USBDHIDKeyboardKeyStateChange returns this value if it is called with the bPress parameter set to false but with a ui8UsageCode parameter which does does not indicate a key that is currently recorded as being pressed. This may occur if an attempt was previously made to report more than 6 pressed keys and the earlier pressed keys are released before the later ones. This condition is benign and should not be used to indicate a host disconnection or serious error.

2.18.2.3 #define KEYB_ERR_TOO_MANY_KEYS

This return code from USBDHIDKeyboardKeyStateChange indicates that an attempt has been made to record more than 6 simultaneously pressed, non-modifier keys. The USB HID BIOS keyboard protocol allows no more than 6 pressed keys to be reported at one time. Until at least one key is released, the device will report a roll over error to the host each time it is asked for the keyboard input report.

2.18.2.4 #define KEYB_ERR_TX_ERROR

This return code from USBDHIDKeyboardKeyStateChange indicates that an error was reported while attempting to send a report to the host. A client should assume that the host has disconnected if this return code is seen.

2.18.2.5 #define KEYB_MAX_CHARS_PER_REPORT

The maximum number of simultaneously-pressed, non-modifier keys that the HID BIOS keyboard protocol can send at once. Attempts to send more pressed keys than this will result in a rollover error being reported to the host and KEYB_ERR_TOO_MANY_KEYS being returned from USBDHIDKeyboardKeyStateChange.

2.18.2.6 #define KEYB_SUCCESS

This return code from USBDHIDKeyboardKeyStateChange indicates success.

2.18.2.7 #define USBD_HID_KEYB_EVENT_SET_LEDS

This event indicates that the keyboard LED states are to be set. The ui32MsgValue parameter contains the requested state for each of the LEDs defined as a collection of ORed bits where a 1 indicates that the LED is to be turned on and a 0 indicates that it should be turned off. The individual LED bits are defined using labels HID_KEYB_NUM_LOCK, HID_KEYB_CAPS_LOCK, HID_KEYB_SCROLL_LOCK, HID_KEYB_COMPOSE and HID_KEYB_KANA.

2.18.3 Function Documentation

2.18.3.1 void * USBDHIDKeyboardCompositeInit (uint32_t *ui32Index*, tUSBDHIDKeyboardDevice * *psHIDKbDevice*, tCompositeEntry * *psCompEntry*)

Initializes HID keyboard device operation for a given USB controller.

Parameters:

ui32Index is the index of the USB controller which is to be initialized for HID keyboard device operation.

psHIDKbDevice points to a structure containing parameters customizing the operation of the HID keyboard device.

psCompEntry is the composite device entry to initialize when creating a composite device.

This call is very similar to USBDKeyboardInit() except that it is used for initializing an instance of the HID keyboard device for use in a composite device. If this HID keyboard

is part of a composite device, then the *psCompEntry* should point to the composite device entry to initialize. This is part of the array that is passed to the USBDCompositeInit() function.

Returns:

Returns zero on failure or a non-zero instance value that should be used with the remaining USB HID Keyboard APIs.

2.18.3.2 void * USBDHIDKeyboardInit (uint32_t *ui32Index*, tUSBDHIDKeyboardDevice * *psHIDKbDevice*)

Initializes HID keyboard device operation for a given USB controller.

Parameters:

ui32Index is the index of the USB controller which is to be initialized for HID keyboard device operation.

psHIDKbDevice points to a structure containing parameters customizing the operation of the HID keyboard device.

An application wishing to offer a USB HID keyboard interface to a USB host must call this function to initialize the USB controller and attach the keyboard device to the USB bus. This function performs all required USB initialization.

On successful completion, this function will return the *psHIDKbDevice* pointer passed to it. This must be passed on all future calls to the HID keyboard device driver.

When a host connects and configures the device, the application callback will receive **USB_EVENT_CONNECTED** after which calls can be made to USBDHIDKeyboardKeyStateChange() to report key presses and releases to the USB host.

Note:

The application must not make any calls to the lower level USB device interfaces if interacting with USB via the USB HID keyboard device class API. Doing so will cause unpredictable (though almost certainly unpleasant) behavior.

Returns:

Returns NULL on failure or the psHIDKbDevice pointer on success.

2.18.3.3 uint32_t USBDHIDKeyboardKeyStateChange (void * *pvKeyboardDevice*, uint8_t *ui8Modifiers*, uint8_t *ui8UsageCode*, bool *bPress*)

Reports a key state change to the USB host.

Parameters:

pvKeyboardDevice is the pointer to the device instance structure as returned by USBDHIDKeyboardInit().

ui8Modifiers contains the states of each of the keyboard modifiers (left/right shift, ctrl, alt or GUI keys). Valid values are logical OR combinations of the labels **HID_KEYB_LEFT_CTRL**, **HID_KEYB_LEFT_SHIFT**, **HID_KEYB_LEFT_ALT**, **HID_KEYB_LEFT_GUI**, **HID_KEYB_RIGHT_CTRL**, **HID_KEYB_RIGHT_SHIFT**, **HID_KEYB_RIGHT_ALT** and **HID_KEYB_RIGHT_GUI**. Presence of one of these bit flags indicates that the relevant modifier key is pressed and absence indicates that it is released.

ui8UsageCode is the usage code of the key whose state has changed. If only modifier keys have changed, **HID_KEYB_USAGE_RESERVED** should be passed in this parameter.

bPress is **true** if the key has been pressed or **false** if it has been released. If only modifier keys have changed state, this parameter is ignored.

This function adds or removes a key usage code from the list of keys currently pressed and schedules a report transmission to the host to inform it of the new keyboard state. If the maximum number of simultaneous key presses are already recorded, the report to the host will contain the rollover error code, HID_KEYB_USAGE_ROLLOVER instead of key usage codes and the caller will receive return code KEYB_ERR_TOO_MANY_KEYS.

Returns:

Returns **KEYB_SUCCESS** if the key usage code was added to or removed from the current list successfully. **KEYB_ERR_TOO_MANY_KEYS** is returned if an attempt is made to press a 7th key (the BIOS keyboard protocol can report no more than 6 simultaneously pressed keys). If called before the USB host has configured the device, **KEYB_ERR_NOT_CONFIGURED** is returned and, if an error is reported while attempting to transmit the report, **KEYB_ERR_TX_ERROR** is returned. If an attempt is made to remove a key from the pressed list (by setting parameter *bPressed* to **false**) but the key usage code is not found, **KEYB_ERR_NOT_FOUND** is returned.

2.18.3.4 void USBDHIDKeyboardPowerStatusSet (void * *pvKeyboardDevice*, uint8_t *ui8Power*)

Reports the device power status (bus or self powered) to the USB library.

Parameters:

pvKeyboardDevice is the pointer to the keyboard device instance structure.

ui8Power indicates the current power status, either **USB_STATUS_SELF_PWR** or **USB_STATUS_BUS_PWR**.

Applications which support switching between bus or self powered operation should call this function whenever the power source changes to indicate the current power status to the USB library. This information is required by the USB library to allow correct responses to be provided when the host requests status from the device.

Returns:

None.

2.18.3.5 bool USBDHIDKeyboardRemoteWakeupRequest (void * *pvKeyboardDevice*)

Requests a remote wake up to resume communication when in suspended state.

Parameters:

pvKeyboardDevice is the pointer to the keyboard device instance structure.

When the bus is suspended, an application which supports remote wake up (advertised to the host via the configuration descriptor) may call this function to initiate remote wake up signaling to the host. If the remote wake up feature has not been disabled by the host, this will cause the bus to resume operation within 20mS. If the host has disabled remote wake up, **false** will be returned to indicate that the wake up request was not successful.

Returns:

Returns **true** if the remote wake up is not disabled and the signaling was started or **false** if remote wake up is disabled or if signaling is currently ongoing following a previous call to this function.

2.18.3.6 void * USBDHIDKeyboardSetCBData (void * *pvKeyboardDevice*, void * *pvCBData*)

Sets the client-specific pointer parameter for the keyboard callback.

Parameters:

pvKeyboardDevice is the pointer to the device instance structure as returned by USBDHIDKeyboardInit().

pvCBData is the pointer that client wishes to be provided on each event sent to the keyboard callback function.

The client uses this function to change the callback pointer passed in the first parameter on all callbacks to the *pfnCallback* function passed on USBDHIDKeyboardInit().
If a client wants to make runtime changes in the callback pointer, it must ensure that the *pvKeyboardDevice* structure passed to USBDHIDKeyboardInit() resides in RAM. If this structure is in flash, callback data changes will not be possible.

Returns:

Returns the previous callback pointer that was set for this instance.

2.18.3.7 void USBDHIDKeyboardTerm (void * *pvKeyboardDevice*)

Shuts down the HID keyboard device.

Parameters:

pvKeyboardDevice is the pointer to the device instance structure as returned by USBDHIDKeyboardInit().

This function terminates HID keyboard operation for the instance supplied and removes the device from the USB bus. Following this call, the *pvKeyboardDevice* instance may not me used in any other call to the HID keyboard device other than USBDHIDKeyboardInit().

Returns:

None.

2.19 Using the USB Device API

If an existing USB Device Class Driver is not suitable for your application, you may choose to develop your device using the lower-level USB Device API instead. This offers greater flexibility but involves somewhat more work. Creating a device application using the USB Device API involves several steps:

- Build device, configuration, interface and endpoint descriptor structures to describe your device.
- Write handlers for each of the USB events your device is interested in receiving from the USB library.
- Call the USB Device API to connect the device to the bus and manage standard host interaction on your behalf.

The following sections walk through each of these steps offering code examples to illustrate the process. Working examples illustrating use of the library can also be found in the DriverLib release for your USB-capable evaluation kit.
The term “device code” used in the following sections describes all class specific code written above the USB Device API to implement a particular USB device application. This may be either application code or a USB device class driver.

2.19.1 Building Descriptors

The USB Device API manages all standard USB descriptors on behalf of the device. These descriptors are provided to the library via three fields in the *tDeviceInfo* structure which is passed on a call to USBDCDInit(). The relevant fields are:

- *psDeviceDescriptor*
- *ppui8StringDescriptors*
- *ui32NumStringDescriptors*

All descriptors are provided as pointers to arrays of uint8_tacters where the contents of the individual descriptor arrays are USB 2.0-compliant descriptors of the appropriate type. For examples of particular descriptors, see the main source files for each of the USB device class drivers (for example `device/usbdbulk.c` for the generic bulk device class driver).

2.19.1.1 tDeviceInfo.pDeviceDescriptor

This array must hold the device descriptor that the USB Device API will return to the host in response to a GET_DESCRIPTOR(DEVICE) request. The following example contains the device descriptor provided by a USB HID keyboard device.

```
tUSBDHIDKeyboardDevice g_sKeyboardDevice =
{
    USB_VID_TI_1CBE,
    USB_PID_KEYBOARD,
    500,
    USB_CONF_ATTR_SELF_PWR | USB_CONF_ATTR_RWAKE,
    KeyboardHandler,
    (void *)&g_sKeyboardDevice,
    g_ppui8StringDescriptors,
    NUM_STRING_DESCRIPTORS,
    0//&g_KeyboardInstance
};
```

Header file `usblib.h` contains macros and labels to help in the construction of descriptors and individual device class header files, such as `usbhid.h` and `device/usbdhid.h` for the Human Interface Device class, provide class specific values and labels.

2.19.1.2 tDeviceInfo.ppui8StringDescriptors

tDeviceInfo.ui32NumStringDescriptors Descriptive strings referenced by device and configuration descriptors are provided to the USB Device API as an array of string descriptors containing the basic descriptor length and type header followed by a Unicode string. The various string identifiers passed in other descriptors are indexes into the *pStringDescriptor* array. The first entry of the string descriptor array has a special format and indicates the languages supported by the device.
The field *ui32NumStringDescriptors* indicates the number of individual string descriptors in the *ppui8StringDescriptors* array.
The string descriptor array provided to the USB Device API for a USB HID keyboard follows.

```
//*****************************************************************************
//
// The languages supported by this device.
//
//*****************************************************************************
const uint8_t g_pui8LangDescriptor[] =
{
    4,
    USB_DTYPE_STRING,
    USBShort(USB_LANG_EN_US)
```

```
};

//*****************************************************************************
//
// The manufacturer string.
//
//*****************************************************************************
const uint8_t g_pui8ManufacturerString[] =
{
    (17 + 1) * 2,
    USB_DTYPE_STRING,
    'T', 0, 'e', 0, 'x', 0, 'a', 0, 's', 0, ' ', 0, 'I', 0, 'n', 0, 's', 0,
    't', 0, 'r', 0, 'u', 0, 'm', 0, 'e', 0, 'n', 0, 't', 0, 's', 0,
};

//*****************************************************************************
//
// The product string.
//
//*****************************************************************************
const uint8_t g_pui8ProductString[] =
{
    (16 + 1) * 2,
    USB_DTYPE_STRING,
    'K', 0, 'e', 0, 'y', 0, 'b', 0, 'o', 0, 'a', 0, 'r', 0, 'd', 0, ' ', 0,
    'E', 0, 'x', 0, 'a', 0, 'm', 0, 'p', 0, 'l', 0, 'e', 0
};

//*****************************************************************************
//
// The serial number string.
//
//*****************************************************************************
const uint8_t g_pui8SeriailNumberString[] =
{
    (8 + 1) * 2,
    USB_DTYPE_STRING,
    '1', 0, '2', 0, '3', 0, '4', 0, '5', 0, '6', 0, '7', 0, '8', 0
};

//*****************************************************************************
//
// The interface description string.
//
//*****************************************************************************
const uint8_t g_pui8HIDInterfaceString[] =
{
    (22 + 1) * 2,
    USB_DTYPE_STRING,
    'H', 0, 'I', 0, 'D', 0, ' ', 0, 'K', 0, 'e', 0, 'y', 0, 'b', 0,
    'o', 0, 'a', 0, 'r', 0, 'd', 0, ' ', 0, 'I', 0, 'n', 0, 't', 0,
    'e', 0, 'r', 0, 'f', 0, 'a', 0, 'c', 0, 'e', 0
```

```
};

//*****************************************************************************
//
// The configuration description string.
//
//*****************************************************************************
const uint8_t g_pui8ConfigString[] =
{
    (26 + 1) * 2,
    USB_DTYPE_STRING,
    'H', 0, 'I', 0, 'D', 0, ' ', 0, 'K', 0, 'e', 0, 'y', 0, 'b', 0,
    'o', 0, 'a', 0, 'r', 0, 'd', 0, ' ', 0, 'C', 0, 'o', 0, 'n', 0,
    'f', 0, 'i', 0, 'g', 0, 'u', 0, 'r', 0, 'a', 0, 't', 0, 'i', 0,
    'o', 0, 'n', 0
};

//*****************************************************************************
//
// The descriptor string table.
//
//*****************************************************************************
const uint8_t * const g_ppui8StringDescriptors[] =
{
    g_pui8LangDescriptor,
    g_pui8ManufacturerString,
    g_pui8ProductString,
    g_pui8SeriailNumberString,
    g_pui8HIDInterfaceString,
    g_pui8ConfigString
};
```

In this example, the *ppui8StringDescriptors* member of the *tDeviceInfo* structure would be initialized with the value *g_ppui8StringDescriptors* and the *ui32NumStringDescriptors* member would be set to the number of elements in the *g_ppui8StringDescriptors* array.

2.19.2 USB Event Handlers

The majority of the work in a USB device application will be carried out either in the context of, or in response to callbacks from the USB Device API. These callback functions are made available to the USB Device API in the *sCallbacks* field of the *tDeviceInfo* structure passed in a call to USBDCDInit().

Field *sCallbacks* is a structure of type *tCustomHandlers* which contains a function pointer for each USB event. The application must populate the table with valid function pointers for each event that it wishes to be informed of. Setting any function pointer to NULL disables notification for that event.

The *tCustomHandlers* structure contains the following fields:

- pfnGetDescriptor
- pfnRequestHandler
- pfnInterfaceChange
- pfnConfigChange
- pfnDataReceived

- pfnDataSent
- pfnResetHandler
- pfnSuspendHandler
- pfnResumeHandler
- pfnDisconnectHandler
- pfnEndpointHandler
- pfnDeviceHandler

Note that all callbacks except the pfnDeviceHandler entry are made in interrupt context. It is, therefore, vital that handlers do not block or make calls to functions which cannot safely be made in an interrupt handler.

2.19.2.1 pfnGetDescriptor

Standard USB device, configuration and string descriptors are handled by the USB Device API internally but some device classes also define additional, class specific descriptors. In cases where the host requests one of these non-standard descriptors, this callback is made to give the device code an opportunity to provide its own descriptor to satisfy the request.
If the device can satisfy the request, it must call USBDCDSendDataEP0() to provide the requested descriptor data to the host. If the request cannot be satisfied, the device should call USBDCDStallEP0() to indicate that the descriptor request is not supported.
If this member of *sCallbacks* is set to NULL, the USB Device API will stall endpoint zero whenever it receives a request for a non-standard descriptor.

2.19.2.2 pfnRequestHandler

The USB Device API contains handlers for all standard USB requests (as defined in Table 9-3 of the USB 2.0 specification) where a standard request is indicated by bits 5 and 6 of the request structure *bmRequestType* field being clear. If a request is received with a non-standard request type, this callback is made to give the device code an opportunity to satisfy the request.
The callback function receives a pointer to a standard, 8 byte request structure of type *tUSBRequest* containing information on the request type, the request identifier and various request-specific parameters. The structure also contains a length field, *wLength*, which indicates how much (if any) data will follow in the data stage of the USB transaction. Note that this data is not available at the time the callback is made and the device code is responsible for requesting it using a call to USBDCDRequestDataEP0() if required.
The sequence required when additional data is attached to the request is as follows:

- Parse the request to determine the request type and verify that it is handled by the device. If not, call USBDCDStallEP0() to indicate the problem.
- If the request is to be handled and *wLength* is non-zero, indicating that additional data is required, call USBDCDRequestDataEP0() passing a pointer to the buffer into which the data is to be written and the number of bytes of data to receive.
- Call USBDevEndpointDataAck() to acknowledge reception of the initial request transmission. This function is found in the Driver Library USB driver API.

Note that it is important to call USBDCDRequestDataEP0() prior to acknowledging the initial request since the acknowledgement frees the host to send the additional data. By making the calls in this order, the USB Device API is guaranteed to be in the correct state to receive the data when it arrives. Making the calls in the opposite order, creates a race condition which could result in loss of data.

Data received as a result of a call to USBDCDRequestDataEP0() will be delivered asynchronously via the *pfnDataReceived* callback described below.
If this member of *sCallbacks* is set to NULL, the USB Device API will stall endpoint zero whenever it receives a non-standard request.

2.19.2.3 pfnInterfaceChange

Based on the configuration descriptor published by the device code, several different alternate interface settings may be supported. In cases where the host wishes to change from the default interface configuration and the USB library determines that the requested alternate setting is supported, this callback is made to inform the device code of the change. The parameters passed provide the new alternate interface (*ucAlternateSetting* and the interface number (*ucInterfaceNum*).
This callback is only made once the USB Device API has validated the requested alternate setting. If the requested setting is not available in the published configuration descriptor, the USB Device API will stall endpoint zero to indicate the error to the host and make no callback to the device code.
If this member of *sCallbacks* is set to NULL, the USB Device API will note the interface change internally but not report it to the device code.

2.19.2.4 pfnConfigChange

When the host enumerates a device, it will ultimately select the configuration that is to be used and send a SET_CONFIGURATION request to the device. When this occurs, the USB Device API validates the configuration number passed against the device code's published configuration descriptors then calls the `pfnConfigChange` callback to inform the device code of the configuration that is to be used.
If this member of *sCallbacks* is set to NULL, the USB Device API will note the configuration change internally but not report it to the device code.

2.19.2.5 pfnDataReceived

This callback informs the device code of the arrival of data following an earlier call to USBDCDRequestDataEP0(). On this callback, the received data will have been written into the buffer provided to the USB Device API in the *pucData* parameter to USBDCDRequestDataEP0().
The callback handler does not need to acknowledge the data using a call to USBDevEndpointDataAck() in this case since this acknowledgement is performed within the USB Device API itself.
If this member of *sCallbacks* is set to NULL, the USB Device API will read endpoint zero data requested via USBDCDRequestDataEP0() but not report its availability to the device code. Devices making use of the USBDCDRequestDataEP0() call must, therefore, ensure that they supply a *pfnDataReceived* handler.

2.19.2.6 pfnDataSent

The USBDCDSendDataEP0() function allows device code to send an arbitrarily-sized block of data to the host via endpoint zero. The maximum packet size that can be sent via endpoint zero is, however, 64 bytes so larger blocks of data are sent in multiple packets. This callback function is used by the USB Device API to inform the device code when all data provided in the buffer passed to USBDCDSendDataEP0() has been consumed and

scheduled for transmission to the host. On reception of this callback, the device code is free to reuse the outgoing data buffer if required.
If this member of *sCallbacks* is set to NULL, the USB Device API will not inform the device code when a block of EP0 data is sent.

2.19.2.7 pfnResetHandler

The *pfnResetHandler* callback is made by the USB Device API whenever a bus reset is detected. This will typically occur during enumeration. The device code may use this notification to perform any housekeeping required in preparation for a new configuration being set.
If this member of *sCallbacks* is set to NULL, the USB Device API will not inform the device code when a bus reset occurs.

2.19.2.8 pfnSuspendHandler

The *pfnSuspendHandler* callback is made whenever the USB Device API detects that suspend has been signalled on the bus. Device code may make use of this notification to, for example, set appropriate power saving modes.
If this member of *sCallbacks* is set to NULL, the USB Device API will not inform the device code when a bus suspend occurs.

2.19.2.9 pfnResumeHandler

The *pfnResumeHandler* callback is made whenever the USB Device API detects that resume has been signalled on the bus. Device code may make use of this notification to undo any changes made in response to an earlier call to the *pfnSuspendHandler* callback.
If this member of *sCallbacks* is set to NULL, the USB Device API will not inform the device code when a bus resume occurs.

2.19.2.10 pfnDisconnectHandler

The *pfnDisconnectHandler* callback is made whenever the USB Device API detects that the device has been disconnected from the bus.
If this member of *sCallbacks* is set to NULL, the USB Device API will not inform the device code when a disconnection event occurs.
Note: The USB_EVENT_DISCONNECTED event will not be reported to the application if the MCU's PB1/USB0VBUS pin is connected to a fixed +5 Volts rather than directly to the VBUS pin on the USB connector or if the USB controller is configured to force device mode.

2.19.2.11 pfnEndpointHandler

While the use of endpoint zero is standardized and supported via several of the other callbacks already listed (*pfnDataSent*, *pfnDataReceived*, *pfnGetDescriptor*, *pfnRequestHandler*, *pfnInterfaceChange* and *pfnConfigChange*), the use of other endpoints is entirely dependent upon the device class being implemented. The *pfnEndpointHandler* callback is, therefore, made to notify the device code of all activity on any endpoint other than endpoint zero and it is the device code's responsibility to determine the correct action to take in response to each callback.

The *ulStatus* parameter passed to the handler provides information on the actual endpoint for which the callback is being made and allows the handler to determine if the event is due to transmission (if an IN endpoint event occurs) or reception (if an OUT endpoint event occurs) of data.
Having determined the endpoint sourcing the event, the device code can determine the actual event by calling USBEndpointStatus() for the appropriate endpoint then clear the status by calling USBDevEndpointStatusClear().
When incoming data is indicated by the flag **USB_DEV_RX_PKT_RDY** being set in the endpoint status, data can be received using a call to USBEndpointDataGet() followed by a call to USBDevEndpointDataAck() to acknowledge the reception to the host.
When an event relating to an IN endpoint (data transmitted from the device to the host) is received, the status read from USBEndpointStatus() indicates any errors in transmission. If the value read is 0, this implies that the data was successfully transmitted and acknowledged by the host.
Any device whose configuration descriptor indicates that it uses any endpoint (endpoint zero use is assumed) must populate the *pfnEndpointHandler* member of *tCustomHandlers*.

2.19.2.12 pfnDeviceHandler

Unlike the other calling functions pfnDeviceHandler specifies a generic input handler to the device class. Callers of this function should check to insure that the class supports this entry by seeing if the pfnDeviceHandler is non-zero This call is provided to allow requests based on a given instance to be passed into a device. This is commonly used by a top level composite device that is using multiple instances of the same class.
USB device classes that need to support being part of a composite device must implement this function as the composite device class will need to call this function to inform the class of interface, endpoint, and string index changes. See the documentation on the USB_EVENT_COMP_IFACE_CHANGE, USB_EVENT_COMP_EP_CHANGE, and USB_EVENT_COMP_STR_CHANGE.

2.19.3 Interrupt Vector Selection

An application using the USB Device API should normally ensure that the interrupt vector for the hardware USB controller is set to call function *USB0DeviceIntHandler*.
If the target application is intended to allow switching between USB device and USB host mode, however, this handler should be replaced with *USB0DualModeIntHandler* to allow the USB library to perform appropriate interrupt steering depending upon the current mode of operation. Hybrid applications must also call USBStackModeSet() to indicate the mode they wish to operate in.

2.19.4 Passing Control to the USB Device API

When all previous setup steps have been completed, control can be passed to the USB Device API. The library will enable the appropriate interrupts and connect the device to the bus in preparation for enumeration by the USB host. This operation is initiated using a call to USBDCDInit() passing the completed *tDeviceInfo* structure which describes the device. Following this call, your device code callback functions will be called when USB events specific to your device are detected by the library.

```
//
// Pass the USB Device API our device information and connect the device
```

```
// the bus.
//
USBDCDInit(0, &g_sMouseDeviceInfo);
```

2.20 USB Device API Definitions

Data Structures

- tCompositeEntry
- tConfigHeader
- tConfigSection
- tCustomHandlers
- tDeviceInfo

Defines

- USB_MAX_INTERFACES_PER_DEVICE

Functions

- void USB0DeviceIntHandler (void)
- void USBDCDDeviceInfoInit (uint32_t ui32Index, tDeviceInfo *psDeviceInfo)
- void USBDCDInit (uint32_t ui32Index, tDeviceInfo *psDevice, void *pvDCDCBData)
- void USBDCDPowerStatusSet (uint32_t ui32Index, uint8_t ui8Power)
- bool USBDCDRemoteWakeupRequest (uint32_t ui32Index)
- void USBDCDRequestDataEP0 (uint32_t ui32Index, uint8_t *pui8Data, uint32_t ui32Size)
- void USBDCDSendDataEP0 (uint32_t ui32Index, uint8_t *pui8Data, uint32_t ui32Size)
- void USBDCDSetDefaultConfiguration (uint32_t ui32Index, uint32_t ui32DefaultConfig)
- void USBDCDStallEP0 (uint32_t ui32Index)
- void USBDCDTerm (uint32_t ui32Index)
- bool USBDeviceConfig (tDCDInstance *psDevInst, const tConfigHeader *psConfig)
- bool USBDeviceConfigAlternate (tDCDInstance *psDevInst, const tConfigHeader *psConfig, uint8_t ui8InterfaceNum, uint8_t ui8AlternateSetting)

2.20.1 Data Structure Documentation

2.20.1.1 tCompositeEntry

Definition:

```
typedef struct
{
    const tDeviceInfo *psDevInfo;
    void *pvInstance;
    uint32_t ui32DeviceWorkspace;
}
tCompositeEntry
```

Members:

psDevInfo This is the top level device information structure.

pvInstance This is the instance data for the device structure.

ui32DeviceWorkspace A per-device workspace used by the composite device.

Description:

This type is used by an application to describe and instance of a device and an instance data pointer for that class. The psDevice pointer should be a pointer to a valid device class to include in the composite device. The pvInstance pointer should be a pointer to an instance pointer for the device in the psDevice pointer.

2.20.1.2 tConfigHeader

Definition:

```
typedef struct
{
    uint8_t ui8NumSections;
    const tConfigSection *const *psSections;
}
tConfigHeader
```

Members:

ui8NumSections The number of sections comprising the full descriptor for this configuration.

psSections A pointer to an array of ui8NumSections section pointers which must be concatenated to form the configuration descriptor.

Description:

This is the top level structure defining a USB device configuration descriptor. A configuration descriptor contains a collection of device- specific descriptors in addition to the basic config, interface and endpoint descriptors. To allow flexibility in constructing the configuration, the descriptor is described in terms of a list of data blocks. The first block must contain the configuration descriptor itself and the following blocks are appended to this in order to produce the full descriptor sent to the host in response to a GetDescriptor request for the configuration descriptor.

2.20.1.3 tConfigSection

Definition:

```
typedef struct
{
    uint16_t ui16Size;
    const uint8_t *pui8Data;
}
tConfigSection
```

Members:

ui16Size The number of bytes of descriptor data pointed to by pui8Data.

pui8Data A pointer to a block of data containing an integral number of USB descriptors which form part of a larger configuration descriptor.

Description:

This structure defines a contiguous block of data which contains a group of descriptors that form part of a configuration descriptor for a device. It is assumed that a config section contains only whole descriptors. It is not valid to split a single descriptor across multiple sections.

2.20.1.4 tCustomHandlers

Definition:

```
typedef struct
{
    tStdRequest pfnGetDescriptor;
    tStdRequest pfnRequestHandler;
    tInterfaceCallback pfnInterfaceChange;
    tInfoCallback pfnConfigChange;
    tInfoCallback pfnDataReceived;
    tInfoCallback pfnDataSent;
    tUSBIntHandler pfnResetHandler;
    tUSBIntHandler pfnSuspendHandler;
    tUSBIntHandler pfnResumeHandler;
    tUSBIntHandler pfnDisconnectHandler;
    tUSBEPIntHandler pfnEndpointHandler;
    tUSBDeviceHandler pfnDeviceHandler;
}
tCustomHandlers
```

Members:

pfnGetDescriptor This callback is made whenever the USB host requests a non-standard descriptor from the device.

pfnRequestHandler This callback is made whenever the USB host makes a non-standard request.

pfnInterfaceChange This callback is made in response to a SetInterface request from the host.

pfnConfigChange This callback is made in response to a SetConfiguration request from the host.

pfnDataReceived This callback is made when data has been received following to a call to USBDCDRequestDataEP0.

pfnDataSent This callback is made when data has been transmitted following a call to USBDCDSendDataEP0.

pfnResetHandler This callback is made when a USB reset is detected.

pfnSuspendHandler This callback is made when the bus has been inactive long enough to trigger a suspend condition.

pfnResumeHandler This is called when resume signaling is detected.

pfnDisconnectHandler This callback is made when the device is disconnected from the USB bus.

pfnEndpointHandler This callback is made to inform the device of activity on all endpoints other than endpoint zero.

pfnDeviceHandler This generic handler is provided to allow requests based on a given instance to be passed into a device. This is commonly used by a top level composite device that is using multiple instances of a class.

Description:

USB event handler functions used during enumeration and operation of the device stack.

2.20.1.5 tDeviceInfo

Definition:

```
typedef struct
{
```

```
    const tCustomHandlers *psCallbacks;
    const uint8_t *pui8DeviceDescriptor;
    const tConfigHeader *const *ppsConfigDescriptors;
    const uint8_t *const *ppui8StringDescriptors;
    uint32_t ui32NumStringDescriptors;
}
tDeviceInfo
```

Members:

psCallbacks A pointer to a structure containing pointers to event handler functions provided by the client to support the operation of this device.

pui8DeviceDescriptor A pointer to the device descriptor for this device.

ppsConfigDescriptors A pointer to an array of configuration descriptor pointers. Each entry in the array corresponds to one configuration that the device may be set to use by the USB host. The number of entries in the array must match the bNumConfigurations value in the device descriptor array, pui8DeviceDescriptor.

ppui8StringDescriptors A pointer to the string descriptor array for this device. This array must be arranged as follows:

HASH(0x1247ae8)

and so on.

ui32NumStringDescriptors The total number of descriptors provided in the ppStringDescriptors array.

Description:

This structure is passed to the USB library on a call to USBDCDInit and provides the library with information about the device that the application is implementing. It contains functions pointers for the various USB event handlers and pointers to each of the standard device descriptors.

2.20.2 Define Documentation

2.20.2.1 USB_MAX_INTERFACES_PER_DEVICE

Definition:

```
#define USB_MAX_INTERFACES_PER_DEVICE
```

Description:

The maximum number of independent interfaces that any single device implementation can support. Independent interfaces means interface descriptors with different bInterfaceNumber values - several interface descriptors offering different alternative settings but the same interface number count as a single interface.

2.20.3 Function Documentation

2.20.3.1 USB0DeviceIntHandler

The USB device interrupt handler.

Prototype:

```
void
USB0DeviceIntHandler(void)
```

Description:

This the main USB interrupt handler entry point for use in USB device applications. This top-level handler will branch the interrupt off to the appropriate application or stack handlers depending on the current status of the USB controller.

Applications which operate purely as USB devices (rather than dual mode applications which can operate in either device or host mode at different times) must ensure that a pointer to this function is installed in the interrupt vector table entry for the USB0 interrupt. For dual mode operation, the vector should be set to point to *USB0DualModeIntHandler()* instead.

Returns:

None.

2.20.3.2 USBDCDDeviceInfoInit

Initialize an instance of the tDeviceInfo structure.

Prototype:

```
void
USBDCDDeviceInfoInit(uint32_t ui32Index,
                     tDeviceInfo *psDeviceInfo)
```

Parameters:

ui32Index is the index of the USB controller which is to be initialized.

psDeviceInfo is a pointer to the tDeviceInfo structure that needs to be initialized. This function must be called by a USB device class instance to initialize the basic tDeviceInfo required for all USB device class modules. This is typically called in the initialization routine for USB device class. For example in usbdaudio.c that supports USB device audio classes, this function is called in the USBDAudioCompositeInit() function which is used for both composite and non-composites instances of the USB audio class.

Note:

This function should not be called directly by applications.

Returns:

None.

2.20.3.3 void USBDCDInit (uint32_t *ui32Index*, tDeviceInfo * *psDevice*, void * *pvDCDCBData*)

Initialize the USB library device control driver for a given hardware controller.

Parameters:

ui32Index is the index of the USB controller which is to be initialized.

psDevice is a pointer to a structure containing information that the USB library requires to support operation of this application's device. The structure contains event handler callbacks and pointers to the various standard descriptors that the device wishes to publish to the host.

pvDCDCBData is the callback data for any device callbacks.

Description:

This function must be called by a device class which wishes to operate as a USB device and is not typically called by an application. This function initializes the USB device control driver for the given controller and saves the device information for future use. Prior to returning from this function, the device is connected to the USB bus. Following return, the caller can expect to receive a callback to the supplied `pfnResetHandler` function when a host connects to the device. The *pvDCDCBData* contains a pointer to data that is returned with the DCD calls back to the function in the psDevice->psCallbacks() functions.

The device information structure passed in *psDevice* must remain unchanged between this call and any matching call to USBDCDTerm() because it is not copied by the USB library.

The USBStackModeSet() function can be called with eUSBModeForceDevice in order to cause the USB library to force the USB operating mode to a device controller. This allows the application to used the USBVBUS and USBID pins as GPIOs on devices that support forcing OTG to operate as a device only controller. By default the USB library will assume that the USBVBUS and USBID pins are configured as USB pins and not GPIOs.

Returns:

None.

2.20.3.4 USBDCDPowerStatusSet

Reports the device power status (bus- or self-powered) to the library.

Prototype:

```
void
USBDCDPowerStatusSet(uint32_t ui32Index,
                     uint8_t ui8Power)
```

Parameters:

ui32Index is the index of the USB controller whose device power status is being reported.

ui8Power indicates the current power status, either **USB_STATUS_SELF_PWR** or **USB_STATUS_BUS_PWR**.

Description:

Applications which support switching between bus- or self-powered operation should call this function whenever the power source changes to indicate the current power status to the USB library. This information is required by the library to allow correct responses to be provided when the host requests status from the device.

Returns:

None.

2.20.3.5 USBDCDRemoteWakeupRequest

Requests a remote wake up to resume communication when in suspended state.

Prototype:

```
bool
USBDCDRemoteWakeupRequest(uint32_t ui32Index)
```

Parameters:

ui32Index is the index of the USB controller that will request a bus wake up.

Description:

When the bus is suspended, an application which supports remote wake up (advertised to the host via the configuration descriptor) may call this function to initiate remote wake up signaling to the host. If the remote wake up feature has not been disabled by the host, this will cause the bus to resume operation within 20mS. If the host has disabled remote wake up, **false** will be returned to indicate that the wake up request was not successful.

Returns:

Returns **true** if the remote wake up is not disabled and the signaling was started or **false** if remote wake up is disabled or if signaling is currently ongoing following a previous call to this function.

2.20.3.6 USBDCDRequestDataEP0

This function starts the request for data from the host on endpoint zero.

Prototype:

```
void
USBDCDRequestDataEP0(uint32_t ui32Index,
                     uint8_t *pui8Data,
                     uint32_t ui32Size)
```

Parameters:

ui32Index is the index of the USB controller from which the data is being requested.

pui8Data is a pointer to the buffer to fill with data from the USB host.

ui32Size is the size of the buffer or data to return from the USB host.

Description:

This function handles retrieving data from the host when a custom command has been issued on endpoint zero. If the application needs notification when the data has been received, `psCallbacks->pfnDataReceived()` in the tDeviceInfo structure must contain valid function pointer. In nearly all cases this is necessary because the caller of this function would likely need to know that the data requested was received.

Returns:

None.

2.20.3.7 USBDCDSendDataEP0

This function requests transfer of data to the host on endpoint zero.

Prototype:

```
void
USBDCDSendDataEP0(uint32_t ui32Index,
                  uint8_t *pui8Data,
                  uint32_t ui32Size)
```

Parameters:

ui32Index is the index of the USB controller which is to be used to send the data.

pui8Data is a pointer to the buffer to send via endpoint zero.

ui32Size is the amount of data to send in bytes.

Description:

This function handles sending data to the host when a custom command is issued or non-standard descriptor has been requested on endpoint zero. If the application needs notification when this is complete, `psCallbacks->pfnDataSent` in the tDeviceInfo structure must contain a valid function pointer. This callback could be used to free up the buffer passed into this function in the *pui8Data* parameter. The contents of the *pui8Data* buffer must remain unchanged until the `pfnDataSent` callback is received.

Returns:

None.

2.20.3.8 USBDCDSetDefaultConfiguration

This function sets the default configuration for the device.

Prototype:

```
void
USBDCDSetDefaultConfiguration(uint32_t ui32Index,
                              uint32_t ui32DefaultConfig)
```

Parameters:

ui32Index is the index of the USB controller whose default configuration is to be set.

ui32DefaultConfig is the configuration identifier (byte 6 of the standard configuration descriptor) which is to be presented to the host as the default configuration in cases

where the configuration descriptor is queried prior to any specific configuration being set.

Description:

This function allows a device to override the default configuration descriptor that will be returned to a host whenever it is queried prior to a specific configuration having been set. The parameter passed must equal one of the configuration identifiers found in the `ppsConfigDescriptors` array for the device.

If this function is not called, the USB library will return the first configuration in the `ppsConfigDescriptors` array as the default configuration.

Note:

The USB device stack assumes that the configuration IDs (byte 6 of the configuration descriptor, `bConfigurationValue`) stored within the configuration descriptor array, `ppsConfigDescriptors`, are equal to the array index + 1. In other words, the first entry in the array must contain a descriptor with `bConfigurationValue` 1, the second must have `bConfigurationValue` 2 and so on.

Returns:

None.

2.20.3.9 USBDCDStallEP0

This function generates a stall condition on endpoint zero.

Prototype:

```
void
USBDCDStallEP0(uint32_t ui32Index)
```

Parameters:

ui32Index is the index of the USB controller whose endpoint zero is to be stalled.

Description:

This function is typically called to signal an error condition to the host when an unsupported request is received by the device. It should be called from within the callback itself (in interrupt context) and not deferred until later since it affects the operation of the endpoint zero state machine in the USB library.

Returns:

None.

2.20.3.10 USBDCDTerm

Free the USB library device control driver for a given hardware controller.

Prototype:

```
void
USBDCDTerm(uint32_t ui32Index)
```

Parameters:

ui32Index is the index of the USB controller which is to be freed.

Description:

This function should be called by an application if it no longer requires the use of a given USB controller to support its operation as a USB device. It frees the controller for use by another client.

It is the caller's responsibility to remove its device from the USB bus prior to calling this function.

Returns:

None.

2.20.3.11 USBDeviceConfig

Configure the USB controller appropriately for the device whose configuration descriptor is passed.

Prototype:

```
bool
USBDeviceConfig(tDCDInstance *psDevInst,
                const tConfigHeader *psConfig)
```

Parameters:

psDevInst is a pointer to the device instance being configured.

psConfig is a pointer to the configuration descriptor that the USB controller is to be set up to support.

Description:

This function may be used to initialize a USB controller to operate as the device whose configuration descriptor is passed. The function enables the USB controller, partitions the FIFO appropriately and configures each endpoint required by the configuration. If the supplied configuration supports multiple alternate settings for any interface, the USB FIFO is set up assuming the worst case use (largest packet size for a given endpoint in any alternate setting using that endpoint) to allow for on-the-fly alternate setting changes later. On return from this function, the USB controller is configured for correct operation of the default configuration of the device described by the descriptor passed.

USBDCDConfig() is an optional call and applications may chose to make direct calls to SysCtlPeripheralEnable(), USBDevEndpointConfigSet() and USBFIFOConfigSet() instead of using this function. If this function is used, it must be called prior to USBDCDInit() since this call assumes that the low level hardware configuration has been completed before it is made.

Returns:

Returns **true** on success or **false** on failure.

2.20.3.12 USBDeviceConfigAlternate

Configure the affected USB endpoints appropriately for one alternate interface setting.

Prototype:

```
bool
USBDeviceConfigAlternate(tDCDInstance *psDevInst,
                         const tConfigHeader *psConfig,
                         uint8_t ui8InterfaceNum,
                         uint8_t ui8AlternateSetting)
```

Parameters:

psDevInst is a pointer to the device instance being configured.

psConfig is a pointer to the configuration descriptor that contains the interface whose alternate settings is to be configured.

ui8InterfaceNum is the number of the interface whose alternate setting is to be configured. This number corresponds to the bInterfaceNumber field in the desired interface descriptor.

ui8AlternateSetting is the alternate setting number for the desired interface. This number corresponds to the bAlternateSetting field in the desired interface descriptor.

Description:

This function may be used to reconfigure the endpoints of an interface for operation in one of the interface's alternate settings. Note that this function assumes that the end-

point FIFO settings will not need to change and only the endpoint mode is changed. This assumption is valid if the USB controller was initialized using a previous call to USBDCDConfig().

In reconfiguring the interface endpoints, any additional configuration bits set in the endpoint configuration other than the direction (**USB_EP_DEV_IN** or **USB_EP_DEV_OUT**) and mode (**USB_EP_MODE_MASK**) are preserved.

Returns:

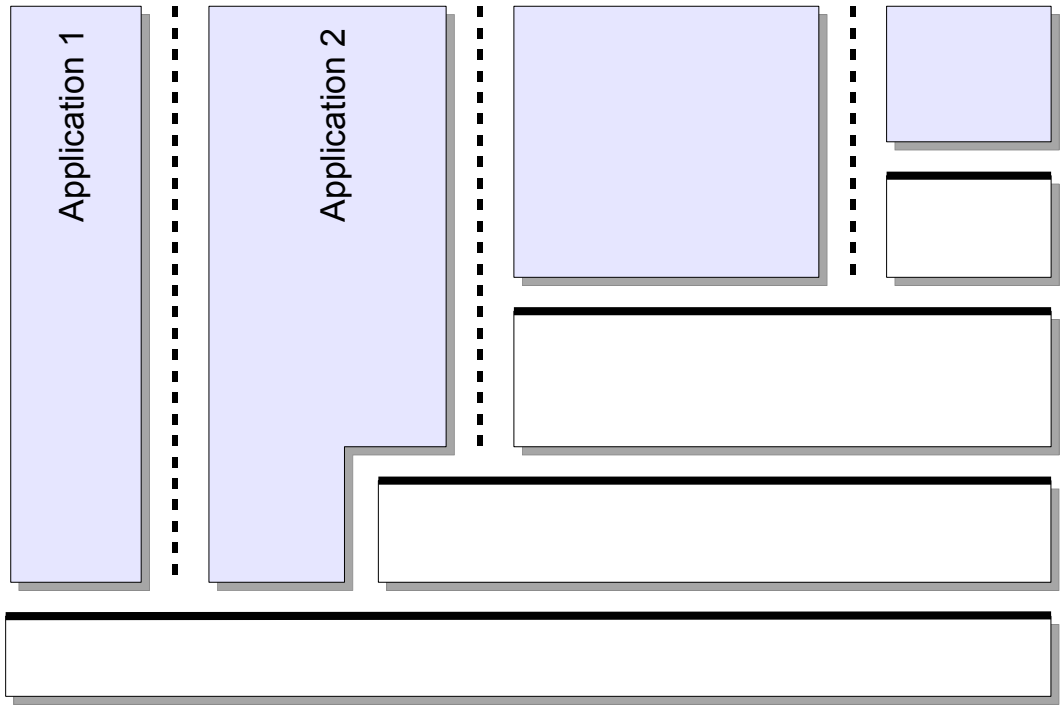
Returns **true** on success or **false** on failure.

3 Host Functions

3.1 Introduction

This chapter covers the support provided by the USB library for the USB controller in host mode. In order to simplify the application and the addition of new devices and device classes, the USB library provides a layered interface to the USB host controller. At the top layer of the USB library there are application interfaces that provide easy access to the various types of peripherals that are supported by the USB library. Below this layer are the USB host controller's device interfaces that handle the specifics of each type of device and how to communicate with the USB host class driver. The USB host class drivers handle the basics of dealing with whole classes of devices like HID and Mass Storage Class devices. The USB host class driver layer communicates with the lowest level of the USB library which is the USB host controller driver. This lowest level directly accesses DriverLib functions to provide communications with the USB device that is connected. This communication is provided by callbacks or direct APIs that is discussed in the rest of this chapter. Much like the USB library's device programming interface, the host interface has the following layers:

- Device APIs (Mouse, Keyboard, Filesystem)
- USB Class Driver APIs (HID, Mass Storage, Hub)
- USB Host Controller APIs
- DriverLib USB Driver APIs



Source Code Overview

Source code and headers for the host specific USB functions can be found in the `host` directory of the USB library tree, typically `libraries/communications/usb/f2838x/include/host` and `libraries/communications/usb/f2838x/source/host`.

`usbhost.h` The header file containing host mode function prototypes and data types offered by the USB library.

`usbhostenum.c` The source code for the USB host enumeration functions offered by the library.

`usbhaudio.c` The source code for the USB host Audio class driver.

`usbhaudio.h` The header file containing Audio class definitions specific to hosts supporting this class of device.

`usbhhid.c` The source code for the USB host HID class driver.

`usbhhid.h` The header file containing the definitions needed to interact with the USB host HID class driver.

`usbhhub.c` The source code for the USB host Hub class driver.

`usbhhub.h` The header file containing the definitions needed to interact with the USB host Hub class driver.

`usbhhidkeyboard.c`
The source code for the USB host HID class keyboard device.

`usbhhidkeyboard.h`
The header file containing the definitions needed to interact with the USB host HID class keyboard device.

`usbhhidmouse.c`
The source code for the USB host HID class mouse device.

`usbhhidmouse.h`
The header file containing the definitions needed to interact with the USB host HID class mouse device.

`usbhmsc.c` The source code for the USB host Mass Storage class driver.

`usbhmsc.h` The header file containing Mass Storage class definitions specific to hosts supporting this class of device.

`usbhscsi.c` The source code for a high level SCSI interface which calls the host Mass Storage class driver.

`usbhscsi.h` The header file containing SCSI interface which calls the host Mass Storage class driver.

3.2 Host Controller Driver

The USB library host controller driver provides an interface to the host controller's hardware register interface. This is the lowest level of the driver interface and it interacts directly with the DriverLib USB APIs. The host controller driver provides all of the functionality necessary to provide enumeration of devices regardless of the type of device that is connected. This portion of the enumeration code only enumerates the device and allows the higher level drivers to actually handle normal device operations. To allow the application to conserve code and data memory, the host controller driver provides a method to allow applications to only include the host class drivers that are needed for each type of USB device. This allows an application to handle multiple classes of devices but only include the USB library code that the application needs to communicate with the devices that the application supports. While the host controller driver handles the enumeration of devices it relies on USB pipes, that are allocated by the higher level class drivers, as the direct communications method with a devices end points.

3.2.1 Enumeration

The USB host controller driver handles all of the details necessary to discover and enumerate any USB device. The USB host controller driver only performs enumeration and relies on the host class drivers to perform any other communications with USB devices including the allocation of the endpoints for the device. Most of the code used to enu-

merate devices is run in interrupt context and is contained in the enumeration handler. In order to complete the enumeration process, the host controller driver also requires that the application periodically call the USBHCDMain() function. When a host class driver or an application needs access to endpoint 0 of a device, it uses the USBHCDControlTransfer() interface to send data to the device or receive data from the device. During the enumeration process the host controller driver searches a list of host class drivers provided by the application in the USBHCDRegisterDrivers() call. The details of this structure are covered in the host class drivers section of this document. If the host controller driver finds a host class driver that matches the class of the enumerated device, it calls the open function for that host class driver. If no host class driver is found the host controller driver ignores the device and there is no notification to the application. The host controller driver or the host class driver can provide callbacks up through the USB library to inform the application of enumeration events. The host class drivers are responsible for configuring the USB pipes based on the type of device that is discovered. The application is notified of events in two ways: one is from the host class driver for the connected device and the other is from a non-device specific event driver. The class specific events come from the host class driver, while the generic connection, power and other non-device class specific events come from the host event driver if it is included in the application. The section "USB Events Driver" covers the host events driver, the valid events and how to include the host events driver in an application.

3.2.2 USB Pipes

The host controller driver layer uses interfaces called USB pipes as the primary method of communications with USB devices. These USB pipes can be dynamically allocated or statically allocated by the USB class drivers during enumeration. The USB pipes are usually only used within the USB library or by host class drivers and are not usually directly accessed by applications. The USB pipes are allocated and freed by calling the USBHCDPipeAlloc() and USBHCDPipeFree() functions and are initially configured by calling the USBHCDPipeConfig(). The USBHCDPipeAlloc() and USBHCDPipeConfig() functions are used during USB device enumeration to allocate USB pipes to specific endpoints of the USB device. On disconnect, the USBHCDPipeFree() function is called to free up the USB pipe for use by a new USB device. While in use, the USB pipes can provide status and perform read and write operations. Calling USBHCDPipeStatus() allows a host class driver to check the status of a pipe. However most access to the USB pipes occurs through USBHCDPipeWrite() and USBHCDPipeRead() and the callback function provided when the USB pipe was allocated. These are used to read or write to endpoints on USB devices on endpoints other than the control endpoint on endpoint 0. Since endpoint 0 is shared with all devices, the host controller interface does not use USB pipes for communications over endpoint 0 and instead uses the USBHCDControlTransfer() function.

3.2.3 Control Transactions

All USB control transactions are handled through the USBHCDControlTransfer() function. This function is primarily used inside the host controller driver itself during enumeration, however some devices may require using control transactions through endpoint 0. The HID class drivers are a good example of a USB class driver that uses control transactions to send data to a USB device. The USBHCDControlTransfer() function should not be called from within interrupt context as control transfers are a blocking operation that relies on interrupts to proceed. Since most callbacks occur in interrupt context, any calls to USBHCDControlTransfer() should be deferred until running outside the callback event. The

USB host HID keyboard example is a good example of performing a control transaction outside of a callback function.

3.2.4 Interrupt Handling

All interrupt handling is done by the USB library host controller driver and most callbacks are done in interrupt context and like interrupt handlers should defer any real processing of events to occur outside the interrupt context. The callbacks are used to notify the upper layers of events that occur during enumeration or during normal operation. Because most of enumeration code is handled by interrupt handlers the enumeration code does require that the application call the USBHCDMain() function in order to progress through the enumeration states without running all code in interrupt context.

3.3 Host Controller Driver Definitions

Data Structures

- struct tUSBHostClassDriver

Defines

- #define DECLARE_EVENT_DRIVER(VarName, pfnOpen, pfnClose, pfnEvent)

Functions

- void USB0HostIntHandler (void)
- uint32_t USBHCDControlTransfer (uint32_t ui32Index, tUSBRequest *psSetupPacket, tUSBHostDevice *psDevice, uint8_t *pui8Data, uint32_t ui32Size, uint32_t ui32MaxPacketSize)
- uint8_t USBHCDDevAddress (uint32_t ui32Instance)
- uint8_t USBHCDDevClass (uint32_t ui32Instance, uint32_t ui32Interface)
- uint8_t USBHCDDevHubPort (uint32_t ui32Instance)
- uint8_t USBHCDDevProtocol (uint32_t ui32Instance, uint32_t ui32Interface)
- uint8_t USBHCDDevSubClass (uint32_t ui32Instance, uint32_t ui32Interface)
- int32_t USBHCDEventDisable (uint32_t ui32Index, void *pvEventDriver, uint32_t ui32Event)
- int32_t USBHCDEventEnable (uint32_t ui32Index, void *pvEventDriver, uint32_t ui32Event)
- void USBHCDInit (uint32_t ui32Index, void *pvPool, uint32_t ui32PoolSize)
- void USBHCDMain (void)
- uint32_t USBHCDPipeAlloc (uint32_t ui32Index, uint32_t ui32EndpointType, tUSBHostDevice *psDevice, tHCDPipeCallback pfnCallback)
- uint32_t USBHCDPipeAllocSize (uint32_t ui32Index, uint32_t ui32EndpointType, tUSBHostDevice *psDevice, uint32_t ui32Size, tHCDPipeCallback pfnCallback)
- uint32_t USBHCDPipeConfig (uint32_t ui32Pipe, uint32_t ui32MaxPayload, uint32_t ui32Interval, uint32_t ui32TargetEndpoint)
- void USBHCDPipeDataAck (uint32_t ui32Pipe)
- void USBHCDPipeFree (uint32_t ui32Pipe)
- uint32_t USBHCDPipeRead (uint32_t ui32Pipe, uint8_t *pui8Data, uint32_t ui32Size)

- uint32_t USBHCDPipeReadNonBlocking (uint32_t ui32Pipe, uint8_t *pui8Data, uint32_t ui32Size)
- uint32_t USBHCDPipeSchedule (uint32_t ui32Pipe, uint8_t *pui8Data, uint32_t ui32Size)
- uint32_t USBHCDPipeStatus (uint32_t ui32Pipe)
- uint32_t USBHCDPipeWrite (uint32_t ui32Pipe, uint8_t *pui8Data, uint32_t ui32Size)
- uint32_t USBHCDPowerAutomatic (uint32_t ui32Index)
- uint32_t USBHCDPowerConfigGet (uint32_t ui32Index)
- void USBHCDPowerConfigInit (uint32_t ui32Index, uint32_t ui32PwrConfig)
- uint32_t USBHCDPowerConfigSet (uint32_t ui32Index, uint32_t ui32Config)
- void USBHCDRegisterDrivers (uint32_t ui32Index, const tUSBHostClassDriver *const *ppsHClassDrvs, uint32_t ui32NumDrivers)
- void USBHCDReset (uint32_t ui32Index)
- void USBHCDResume (uint32_t ui32Index)
- void USBHCDSetAddress (uint32_t ui32DevIndex, uint32_t ui32DevAddress)
- void USBHCDSetConfig (uint32_t ui32Index, uint32_t ui32Device, uint32_t ui32Configuration)
- void USBHCDSetInterface (uint32_t ui32Index, uint32_t ui32Device, uint32_t ui32Interface, uint32_t ui32AltSetting)
- void USBHCDSuspend (uint32_t ui32Index)
- void USBHCDTerm (uint32_t ui32Index)

3.3.1 Detailed Description

The macros and functions defined in this section can be found in header file `host/usbhost.h`.

3.3.2 Define Documentation

3.3.2.1 #define DECLARE_EVENT_DRIVER(VarName, pfnOpen, pfnClose, pfnEvent)

This macro is used to declare an instance of an Event driver for the USB library.

Parameters:

VarName is the name of the variable.

pfnOpen is the callback for the Open call to this driver. This value is currently reserved and should be set to 0.

pfnClose is the callback for the Close call to this driver. This value is currently reserved and should be set to 0.

pfnEvent is the callback that will be called for various USB events.

The first parameter is the actual name of the variable that will be declared by this macro. The second and third parameter are reserved for future functionality and are unused and should be set to zero. The last parameter is the actual callback function and is specified as a function pointer of the type:
void (*pfnEvent)(void *pvData);
When the *pfnEvent* function is called the void pointer that is passed in as a parameter should be cast to a pointer to a structure of type tEventInfo. This will contain the event that caused the pfnEvent function to be called.

3.3.3 Function Documentation

3.3.3.1 void USB0HostIntHandler (void)

The USB host mode interrupt handler for controller index 0.
This the main USB interrupt handler entry point. This handler will branch the interrupt off to the appropriate handlers depending on the current status of the USB controller. This function must be placed in the interrupt table in order for the USB Library host stack to function.

Returns:

None.

3.3.3.2 uint32_t USBHCDControlTransfer (uint32_t *ui32Index*, tUSBRequest * *psSetupPacket*, tUSBHostDevice * *psDevice*, uint8_t * *pui8Data*, uint32_t *ui32Size*, uint32_t *ui32MaxPacketSize*)

This function completes a control transaction to a device.

Parameters:

ui32Index is the controller index to use for this transfer.

psSetupPacket is the setup request to be sent.

psDevice is the device instance pointer for this request.

pui8Data is the data to send for OUT requests or the receive buffer for IN requests.

ui32Size is the size of the buffer in *pui8Data*.

ui32MaxPacketSize is the maximum packet size for the device for this request.

This function handles the state changes necessary to send a control transaction to a device. This function should not be called from within an interrupt callback as it is a blocking function.

Returns:

The number of bytes of data that were sent or received as a result of this request.

3.3.3.3 uint8_t USBHCDDevAddress (uint32_t *ui32Instance*)

This function will return the USB address for the requested device instance.

Parameters:

ui32Instance is a unique value indicating which device to query.

This function returns the USB address for the device that is associated with the *ui32Instance* parameter. The caller must use a value for *ui32Instance* have been passed to the application when it receives a **USB_EVENT_CONNECTED** event. The function will return the USB address for the interface number specified by the *ui32Interface* parameter.

Returns:

The USB address for the requested interface.

3.3.3.4 uint8_t USBHCDDevClass (uint32_t *ui32Instance*, uint32_t *ui32Interface*)

This function will return the USB class for the requested device instance.

Parameters:

ui32Instance is a unique value indicating which device to query.

ui32Interface is the interface number to query for the USB class.

This function returns the USB class for the device that is associated with the *ui32Instance* parameter. The caller must use a value for *ui32Instance* have been passed to the application when it receives a USB_EVENT_CONNECTED event. The function will return the USB class for the interface number specified by the *ui32Interface* parameter. If *ui32Interface* is set to 0xFFFFFFFF then the function will return the USB class for the first interface that is found in the device's USB descriptors.

Returns:

The USB class for the requested interface.

3.3.3.5 uint8_t USBHCDDevHubPort (uint32_t *ui32Instance*)

This function returns the USB hub port for the requested device instance.

Parameters:

ui32Instance is a unique value indicating which device to query.

This function returns the USB hub port for the device that is associated with the *ui32Instance* parameter. The caller must use the value for *ui32Instance* was passed to the application when it receives a USB_EVENT_CONNECTED event. The function returns the USB hub port for the interface number specified by the *ui32Interface* parameter.

Returns:

The USB hub port for the requested interface.

3.3.3.6 uint8_t USBHCDDevProtocol (uint32_t *ui32Instance*, uint32_t *ui32Interface*)

This function returns the USB protocol for the requested device instance.

Parameters:

ui32Instance is a unique value indicating which device to query.

ui32Interface is the interface number to query for the USB protocol.

This function returns the USB protocol for the device that is associated with the *ui32Instance* parameter. The caller must use a value for *ui32Instance* have been passed to the application when it receives a USB_EVENT_CONNECTED event. The function will return the USB protocol for the interface number specified by the *ui32Interface* parameter. If *ui32Interface* is set to 0xFFFFFFFF then the function will return the USB protocol for the first interface that is found in the device's USB descriptors.

Returns:

The USB protocol for the requested interface.

3.3.3.7 uint8_t USBHCDDevSubClass (uint32_t *ui32Instance*, uint32_t *ui32Interface*)

This function will return the USB subclass for the requested device instance.

Parameters:

ui32Instance is a unique value indicating which device to query.

ui32Interface is the interface number to query for the USB subclass.

This function returns the USB subclass for the device that is associated with the *ui32Instance* parameter. The caller must use a value for *ui32Instance* have been passed to the application when it receives a **USB_EVENT_CONNECTED** event. The function will return the USB subclass for the interface number specified by the *ui32Interface* parameter. If *ui32Interface* is set to 0xFFFFFFFF then the function will return the USB subclass for the first interface that is found in the device's USB descriptors.

Returns:
The USB subclass for the requested interface.

3.3.3.8 int32_t USBHCDEventDisable (uint32_t *ui32Index*, void * *pvEventDriver*, uint32_t *ui32Event*)

This function is called to disable a specific USB HCD event notification.
Parameters:
ui32Index specifies which USB controller to use.
pvEventDriver is the event driver structure that was passed into the USBHCDRegisterDrivers() function as part of the array of tUSBHostClassDriver structures.
ui32Event is the event to disable.

This function is called to disable event callbacks for a specific USB HCD event. The requested event is passed in the *ui32Event* parameter. Not all events can be enables so the function will return zero if the event provided cannot be enabled. The *pvEventDriver* is a pointer to the event driver structure that the caller passed into the USBHCDRegisterDrivers() function. This structure is typically declared with the DECLARE_EVENT_DRIVER() macro and included as part of the array of pointers to tUSBHostClassDriver structures that is passed to the USBHCDRegisterDrivers() function.
Returns:
This function returns a non-zero number if the event was successfully disabled and returns zero if the event cannot be disabled.

3.3.3.9 int32_t USBHCDEventEnable (uint32_t *ui32Index*, void * *pvEventDriver*, uint32_t *ui32Event*)

This function is called to enable a specific USB HCD event notification.
Parameters:
ui32Index specifies which USB controller to use.
pvEventDriver is the event driver structure that was passed into the USBHCDRegisterDrivers() function as part of the array of tUSBHostClassDriver structures.
ui32Event is the event to enable.

This function is called to enable event callbacks for a specific USB HCD event. The requested event is passed in the *ui32Event* parameter. Not all events can be enables so the function will return zero if the event provided cannot be enabled. The *pvEventDriver* is a pointer to the event driver structure that the caller passed into the USBHCDRegisterDrivers() function. This structure is typically declared with the DECLARE_EVENT_DRIVER() macro and included as part of the array of pointers to tUSBHostClassDriver structures that is passed to the USBHCDRegisterDrivers() function.
Returns:
This function returns a non-zero number if the event was successfully enabled and returns zero if the event cannot be enabled.

3.3.3.10 void USBHCDInit (uint32_t *ui32Index*, void * *pvPool*, uint32_t *ui32PoolSize*)

This function is used to initialize the HCD code.
Parameters:
ui32Index specifies which USB controller to use.
pvPool is a pointer to the data to use as a memory pool for this controller.

ui32PoolSize is the size in bytes of the buffer passed in as *pvPool*.

This function will perform all the necessary operations to allow the USB host controller to begin enumeration and communication with devices. This function should typically be called once at the start of an application once all of the device and class drivers are ready for normal operation. This call will start up the USB host controller and any connected device will immediately start the enumeration sequence.

The USBStackModeSet() function can be called with eUSBModeHost in order to cause the USB library to force the USB operating mode to a host controller. This allows the application to used the USBVBUS and USBID pins as GPIOs on devices that support forcing OTG to operate as a host only controller. By default the USB library will assume that the USBVBUS and USBID pins are configured as USB pins and not GPIOs.

The memory pool passed to this function must be at least as large as a typical configuration descriptor for devices that are to be supported. This value is application-dependent however it should never be less than 32 bytes and, in most cases, should be at least 64 bytes. If there is not sufficient memory to load a configuration descriptor from a device, the device will not be recognized by the USB library's host controller driver.

Returns:

None.

3.3.3.11 void USBHCDMain (void)

This function is the main routine for the Host Controller Driver.

This function is the main routine for the host controller driver, and must be called periodically by the main application outside of a callback context. This allows for a simple cooperative system to access the the host controller driver interface without the need for an RTOS. All time critical operations are handled in interrupt context but all blocking operations are run from the this function to allow them to block and wait for completion without holding off other interrupts.

Returns:

None.

3.3.3.12 uint32_t USBHCDPipeAlloc (uint32_t *ui32Index*, uint32_t *ui32EndpointType*, tUSBHostDevice * *psDevice*, tHCDPipeCallback *pfnCallback*)

This function is used to allocate a USB HCD pipe.

Parameters:

ui32Index specifies which USB controller to use.

ui32EndpointType is the type of endpoint that this pipe will be communicating with.

psDevice is the device instance associated with this endpoint.

pfnCallback is the function that will be called when events occur on this USB Pipe.

Since there are a limited number of USB HCD pipes that can be used in the host controller, this function is used to temporarily or permanently acquire one of the endpoints. It also provides a method to register a callback for status changes on this endpoint. If no callbacks are desired then the *pfnCallback* function should be set to 0. The callback should be used when using the USBHCDPipeSchedule() function so that the caller is notified when the action is complete.

Returns:

This function returns a value indicating which pipe was reserved. If the value is 0 then there were no pipes currently available. This value should be passed to any USBHCDPipe APIs to indicate which pipe is being accessed.

3.3.3.13 uint32_t USBHCDPipeAllocSize (uint32_t *ui32Index*, uint32_t *ui32EndpointType*, tUSBHostDevice * *psDevice*, uint32_t *ui32Size*, tHCDPipeCallback *pfnCallback*)

This function is used to allocate a USB HCD pipe.

Parameters:

ui32Index specifies which USB controller to use.

ui32EndpointType is the type of endpoint that this pipe will be communicating with.

psDevice is the device instance associated with this endpoint.

ui32Size is the size of the FIFO in bytes.

pfnCallback is the function that will be called when events occur on this USB Pipe.

Since there are a limited number of USB HCD pipes that can be used in the host controller, this function is used to temporarily or permanently acquire one of the endpoints. Unlike the USBHCDPipeAlloc() function this function allows the caller to specify the size of the FIFO allocated to this endpoint in the *ui32Size* parameter. This function also provides a method to register a callback for status changes on this endpoint. If no callbacks are desired then the *pfnCallback* function should be set to 0. The callback should be used when using the USBHCDPipeSchedule() function so that the caller is notified when the action is complete.

Returns:

This function returns a value indicating which pipe was reserved. If the value is 0 then there were no pipes currently available. This value should be passed to any USBHCDPipe APIs to indicate which pipe is being accessed.

3.3.3.14 uint32_t USBHCDPipeConfig (uint32_t *ui32Pipe*, uint32_t *ui32MaxPayload*, uint32_t *ui32Interval*, uint32_t *ui32TargetEndpoint*)

This function is used to configure a USB HCD pipe.

This should be called after allocating a USB pipe with a call to USBHCDPipeAlloc(). It is used to set the configuration associated with an endpoint like the max payload and target endpoint. The *ui32MaxPayload* parameter is typically read directly from the devices endpoint descriptor and is expressed in bytes.

Setting the *ui32Interval* parameter depends on the type of endpoint being configured. For endpoints that do not need to use the *ui32Interval* parameter *ui32Interval* should be set to 0. For Bulk *ui32Interval* is a value from 2-16 and will set the NAK timeout value as 2^(*ui32Interval-1*) frames. For interrupt endpoints *ui32Interval* is a value from 1-255 and is the count in frames between polling the endpoint. For isochronous endpoints *ui32Interval* ranges from 1-16 and is the polling interval in frames represented as 2^(*ui32Interval-1*) frames.

Parameters:

ui32Pipe is the allocated endpoint to modify.

ui32MaxPayload is maximum data that can be handled per transaction.

ui32Interval is the polling interval for data transfers expressed in frames.

ui32TargetEndpoint is the target endpoint on the device to communicate with.

Returns:

If the call was successful, this function returns zero any other value indicates an error.

3.3.3.15 void USBHCDPipeDataAck (uint32_t *ui32Pipe*)

This function acknowledges data received via an interrupt IN pipe.

Parameters:

ui32Pipe is the USB INT pipe whose last packet is to be acknowledged.

This function is used to acknowledge reception of data on an interrupt IN pipe. A transfer on an interrupt IN endpoint is scheduled via a call to USBHCDPipeSchedule() and the application is notified when data is received using a **USB_EVENT_RX_AVAILABLE** event. In the handler for this event, the application must call USBHCDPipeDataAck() to have the USB controller ACK the data from the device and complete the transaction.

Returns:

None.

3.3.3.16 void USBHCDPipeFree (uint32_t *ui32Pipe*)

This function is used to release a USB pipe.

Parameters:

ui32Pipe is the allocated USB pipe to release.

This function is used to release a USB pipe that was allocated by a call to USBHCDPipeAlloc() for use by some other device endpoint in the system. Freeing an unallocated or invalid pipe will not generate an error and will instead simply return.

Returns:

None.

3.3.3.17 uint32_t USBHCDPipeRead (uint32_t *ui32Pipe*, uint8_t * *pui8Data*, uint32_t *ui32Size*)

This function is used to read data from a USB HCD pipe.

Parameters:

ui32Pipe is the USB pipe to read data from.

pui8Data is a pointer to store the data that is received.

ui32Size is the size in bytes of the buffer pointed to by *pui8Data*.

This function will block and will only return when it has read as much data as requested from the USB pipe. The caller must register a callback with the USBHCDPipeAlloc() call in order to be informed when the data has been received. If the caller provides a non-zero pointer in the *pui8Data* parameter then the data is copied into the buffer before the callback occurs. If the caller provides a zero in *pui8Data* parameter then the caller is responsible for reading the data out of the FIFO when the **USB_EVENT_RX_AVAILABLE** callback event occurs. The value returned by this function can be less than the *ui32Size* requested if the USB pipe has less data available than was requested.

Returns:

This function returns the number of bytes that were returned in the *pui8Data* buffer.

3.3.3.18 uint32_t USBHCDPipeReadNonBlocking (uint32_t *ui32Pipe*, uint8_t * *pui8Data*, uint32_t *ui32Size*)

This function is used to read data from a USB HCD pipe.

Parameters:

ui32Pipe is the USB pipe to read data from.

pui8Data is a pointer to store the data that is received.

ui32Size is the size in bytes of the buffer pointed to by *pui8Data*.

This function will not block and will only read as much data as requested or as much data is currently available from the USB pipe. The caller should have registered a callback with the USBHCDPipeAlloc() call in order to be informed when the data has been received. The value returned by this function can be less than the *ui32Size* requested if the USB pipe has less data available than was requested.

Returns:

This function returns the number of bytes that were returned in the *pui8Data* buffer.

3.3.3.19 uint32_t USBHCDPipeSchedule (uint32_t *ui32Pipe*, uint8_t * *pui8Data*, uint32_t *ui32Size*)

This function is used to schedule and IN transaction on a USB HCD pipe.

Parameters:

ui32Pipe is the USB pipe to read data from.

pui8Data is a pointer to store the data that is received.

ui32Size is the size in bytes of the buffer pointed to by *pui8Data*.

This function will not block depending on the type of pipe passed in will schedule either a send of data to the device or a read of data from the device. In either case the amount of data will be limited to what will fit in the FIFO for a given endpoint.

Returns:

This function returns the number of bytes that were sent in the case of a transfer of data or it will return 0 for a request on a USB IN pipe.

3.3.3.20 uint32_t USBHCDPipeStatus (uint32_t *ui32Pipe*)

This function is used to return the current status of a USB HCD pipe.

This function will return the current status for a given USB pipe. If there is no status to report this call will simply return **USBHCD_PIPE_NO_CHANGE**.

Parameters:

ui32Pipe is the USB pipe for this status request.

Returns:

This function returns the current status for the given endpoint. This will be one of the **USBHCD_PIPE_*** values.

3.3.3.21 uint32_t USBHCDPipeWrite (uint32_t *ui32Pipe*, uint8_t * *pui8Data*, uint32_t *ui32Size*)

This function is used to write data to a USB HCD pipe.

Parameters:

ui32Pipe is the USB pipe to put data into.

pui8Data is a pointer to the data to send.

ui32Size is the amount of data to send.

This function will block until it has sent as much data as was requested using the USB pipe's FIFO. The caller should have registered a callback with the USBHCDPipeAlloc() call in order to be informed when the data has been transmitted. The value returned by this function can be less than the *ui32Size* requested if the USB pipe has less space available than this request is making.

Returns:

This function returns the number of bytes that were scheduled to be sent on the given USB pipe.

3.3.3.22 uint32_t USBHCDPowerAutomatic (uint32_t *ui32Index*)

This function returns if the current power settings will automatically handle enabling and disabling VBUS power.

Parameters:

ui32Index specifies which USB controller to query.

This function returns if the current power control pin configuration will automatically apply power or whether it will be left to the application to turn on power when it is notified.

Returns:

A non-zero value indicates that power is automatically applied and a value of zero indicates that the application must manually apply power.

3.3.3.23 uint32_t USBHCDPowerConfigGet (uint32_t *ui32Index*)

This function is used to get the power pin and power fault configuration.

Parameters:

ui32Index specifies which USB controller to use.

This function will return the current power control pin configuration as set by the USBHCDPowerConfigInit() function or the defaults if not yet set. See the USBHCDPowerConfigInit() documentation for the meaning of the bits that are returned by this function.

Returns:

The configuration of the power control pins.

3.3.3.24 void USBHCDPowerConfigInit (uint32_t *ui32Index*, uint32_t *ui32PwrConfig*)

This function is used to set the power pin and power fault configuration.

Parameters:

ui32Index specifies which USB controller to use.

ui32PwrConfig is the power configuration to use for the application.

This function must be called before HCDInit() is called so that the power pin configuration can be set before power is enabled. The *ui32PwrConfig* flags specify the power fault level sensitivity, the power fault action, and the power enable pin level and source.

One of the following can be selected as the power fault level sensitivity:

- **USBHCD_FAULT_LOW** - An external power fault is indicated by the pin being driven low.
- **USBHCD_FAULT_HIGH** - An external power fault is indicated by the pin being driven high.

One of the following can be selected as the power fault action:

- **USBHCD_FAULT_VBUS_NONE** - No automatic action when power fault detected.
- **USBHCD_FAULT_VBUS_TRI** - Automatically Tri-state the USBnEPEN pin on a power fault.
- **USBHCD_FAULT_VBUS_DIS** - Automatically drive the USBnEPEN pin to it's inactive state on a power fault.

One of the following can be selected as the power enable level and source:

- **USBHCD_VBUS_MANUAL** - Power control is completely managed by the application, the USB library will provide a power callback to request power state changes.
- **USBHCD_VBUS_AUTO_LOW** - USBEPEN is driven low by the USB controller automatically if USBOTGSessionRequest() has enabled a session.

- **USBHCD_VBUS_AUTO_HIGH** - USBEPEN is driven high by the USB controller automatically if USBOTGSessionRequest() has enabled a session.

If **USBHCD_VBUS_MANUAL** is used then the application must provide an event driver to receive the **USB_EVENT_POWER_ENABLE** and **USB_EVENT_POWER_DISABLE** events and enable and disable power to VBUS when requested by the USB library. The application should respond to a power control callback by enabling or disabling VBUS as soon as possible and before returning from the callback function.

Note:

The following values should no longer be used with the USB library: **USB_HOST_PWRFLT_LOW**, **USB_HOST_PWRFLT_HIGH**, **USB_HOST_PWRFLT_EP_NONE**, **USB_HOST_PWRFLT_EP_TRI**, **USB_HOST_PWRFLT_EP_LOW**, **USB_HOST_PWRFLT_EP_HIGH**, **USB_HOST_PWREN_LOW**, **USB_HOST_PWREN_HIGH**, **USB_HOST_PWREN_VBLOW**, and **USB_HOST_PWREN_VBHIGH**.

Returns:

None.

3.3.3.25 uint32_t USBHCDPowerConfigSet (uint32_t *ui32Index*, uint32_t *ui32Config*)

This function is used to set the power pin and power fault configuration.

Parameters:

ui32Index specifies which USB controller to use.

ui32Config specifies which USB power configuration to use.

This function will set the current power control pin configuration as set by the USBHCDPowerConfigInit() function or the defaults if not yet set. See the USBHCDPowerConfigInit() documentation for the meaning of the bits that are set by this function.

Returns:

Returns zero to indicate the power setting is now active.

3.3.3.26 void USBHCDRegisterDrivers (uint32_t *ui32Index*, const tUSBHostClassDriver *const * *ppsHClassDrvs*, uint32_t *ui32NumDrivers*)

This function is used to initialize the HCD class driver list.

Parameters:

ui32Index specifies which USB controller to use.

ppsHClassDrvs is an array of host class drivers that are supported on this controller.

ui32NumDrivers is the number of entries in the *pHostClassDrivers* array.

This function will set the host classes supported by the host controller specified by the *ui32Index* parameter. This function should be called before enabling the host controller driver with the USBHCDInit() function.

Returns:

None.

3.3.3.27 void USBHCDReset (uint32_t *ui32Index*)

This function generates reset signaling on the USB bus.

Parameters:

ui32Index specifies which USB controller to use.

This function handles sending out reset signaling on the USB bus. After returning from this function, any attached device on the USB bus should have returned to it's reset state.

Returns:

None.

3.3.3.28 void USBHCDResume (uint32_t *ui32Index*)

This function will generate resume signaling on the USB bus.

Parameters:

ui32Index specifies which USB controller to use.

This function is used to generate resume signaling on the USB bus in order to cause USB devices to leave their suspended state. This call should not be made unless a preceding call to USBHCDSuspend() has been made.

Returns:

None.

3.3.3.29 void USBHCDSetAddress (uint32_t *ui32DevIndex*, uint32_t *ui32DevAddress*)

This function is used to send the set address command to a device.

Parameters:

ui32DevIndex is the index of the device whose address is to be set. This value must be 0 to indicate that the device is connected directly to the host controller. Higher values indicate devices connected via a hub.

ui32DevAddress is the new device address to use for a device.

The USBHCDSetAddress() function is used to set the USB device address, once a device has been discovered on the bus. This call is typically issued following a USB reset triggered by a call the USBHCDReset(). The address passed into this function via the *ui32DevAddress* parameter is used for all further communications with the device after this function returns.

Returns:

None.

3.3.3.30 void USBHCDSetConfig (uint32_t *ui32Index*, uint32_t *ui32Device*, uint32_t *ui32Configuration*)

This function is used to set the current configuration for a device.

Parameters:

ui32Index specifies which USB controller to use.

ui32Device is the USB device for this function.

ui32Configuration is one of the devices valid configurations.

This function is used to set the current device configuration for a USB device. The *ui32Configuration* value must be one of the configuration indexes that was returned in the configuration descriptor from the device, or a value of 0. If 0 is passed in, the device will return to it's addressed state and no longer be in a configured state. If the value is non-zero then the device will change to the requested configuration.

Returns:

None.

3.3.3.31 void USBHCDSetInterface (uint32_t *ui32Index*, uint32_t *ui32Device*, uint32_t *ui32Interface*, uint32_t *ui32AltSetting*)

This function is used to set the current interface and alternate setting for an interface on a device.

Parameters:

ui32Index specifies which USB controller to use.

ui32Device is the USB device for this function.

ui32Interface is one of the valid interface numbers for a device.

ui32AltSetting is one of the valid alternate interfaces for the *ui32Interface* number.

This function is used to change the alternate setting for one of the valid interfaces on a USB device. The *ui32Device* specifies the device instance that was returned when the device was connected. This call will set the USB device's interface based on the *ui32Interface* and *ui32AltSetting*.

Example: Set the USB device interface 2 to alternate setting 1.

```
USBHCDSetInterface(0, ui32Device, 2, 1);
```

Returns:

None.

3.3.3.32 void USBHCDSuspend (uint32_t *ui32Index*)

This function will generate suspend signaling on the USB bus.

Parameters:

ui32Index specifies which USB controller to use.

This function is used to generate suspend signaling on the USB bus. In order to leave the suspended state, the application should call USBHCDResume().

Returns:

None.

3.3.3.33 void USBHCDTerm (uint32_t *ui32Index*)

This function is used to terminate the HCD code.

Parameters:

ui32Index specifies which USB controller to release.

This function will clean up the USB host controller and disable it in preparation for shutdown or a switch to USB device mode. Once this call is made, *USBHCDInit()* may be called to reinitialize the controller and prepare for host mode operation.

Returns:

None.

3.4 Host Class Driver

The host class drivers provide access to devices that use a common USB class interface. The USB library currently supports the following two USB class drivers: Mass Storage Class(MSC) and Human Interface Device(HID). In order to use these class drivers, the application must provide a list of the host class drivers that it uses by calling the USBHCDRegisterDrivers() function. The g_USBHIDClassDriver structure defines the interface for the Host HID class driver and the g_USBHostMSCClassDriver structure defines the interface for the Host MSC class driver.

The host class driver provides interfaces at its bottom layer to the USB host controller driver and device specific interfaces at it's top layer. The lower layer interface to the USB host controller interface is the same for all USB host class drivers while the device interface layer on top is common to all USB host device interface of a given class. Thus the top layer of the of the MSC class driver does not need to match the top layer of the HID class driver, however the lower layer must be the same for both. Aside from enumeration, all communication with the host class driver is through its endpoint pipes. The host class driver parses and allocate any endpoints that it needs by calling the USBHCDPipeAlloc() and USBHCDPipeConfig() functions. These USB pipes provide the methods to read/write and get callback notification from the USB host controller driver layer.

3.4.1 USB Events Driver

The USB host library includes a method to receive non-device class specific events in the application by using a USB event driver. This driver can be included in applications by declaring an instance of the USB event driver using the DECLARE_EVENT_DRIVER macro and then adding the variable that is declared to the list of drivers supported by the application. This event driver allows applications to notify users that an unsupported device has been inserted or to provide notification that a power fault has occurred and power may have been shut off, depending on the settings provided to the USBHCDPowerConfigInit() function. Depending on configuration the following events can occur:

- **USB_EVENT_CONNECTED** indicates that a support device has been connected.
- **USB_EVENT_UNKNOWN_CONNECTED** indicates that an unsupported device has been connected.
- **USB_EVENT_DISCONNECTED** indicates that an unsupported device has been disconnected.
- **USB_EVENT_POWER_FAULT** indicates that a power fault has occurred.
- **USB_EVENT_POWER_ENABLE** indicates that power should be enabled by the application since it has requested to manually control the power.
- **USB_EVENT_POWER_DISABLE** indicates that power should be enabled by the application since it has requested to manually control the power.
- **USB_EVENT_SOF** indicates that a SOF event has occurred(default disabled).

The USB host library provides the ability to enable or disable any of these events by calling the USBHCDEventEnable() or USBHCDEventDisable() functions. All events except the **USB_EVENT_SOF** are enabled by default when the USB host library is initialized. The **USB_EVENT_SOF** event is left disabled by default to avoid the excess overhead because this event occurs once per millisecond.

Because the USB events driver reuses the interrupt handler callback that is used for a normal host controller drivers, the application is required to cast the void pointer that is passed in to the function to a pointer to a tEventInfo structure. The following code example shows a basic implementation of a USB library event driver callback function.

Example: A USB Event Driver Callback Function

```
//
// Declare the driver.
//
DECLARE_EVENT_DRIVER(g_sEventDriver, 0, 0, USBHCDEvents)

void
USBHCDEvents(void *pvData)
{
    tEventInfo *psEventInfo;

    //
```

```
    // Cast this pointer to its actual type.
    //
    psEventInfo = (tEventInfo *)pvData;

    switch(psEventInfo->ui32Event)
    {
        //
        // Unknown device connected.
        //
        case USB_EVENT_CONNECTED:
        {
            ...

            break;
        }

        //
        // Unknown device disconnected.
        //
        case USB_EVENT_DISCONNECTED:
        {
            ...

            break;
        }

        //
        // Power Fault detected.
        //
        case USB_EVENT_POWER_FAULT:
        {
            ...

            break;
        }

        default:
        {
            break;
        }
    }
}
```

3.4.2 Hub Class Driver

The USB Hub class driver provides support for a USB hub device that allows the USB controller to communicate with multiple USB devices. The maximum number of devices that are supported is controlled by the **MAX_USB_DEVICES** definition in usblib.h. The value defined by **MAX_USB_DEVICES** defaults to 5, meaning that the USB library supports one hub and four other devices. Cascaded USB hubs are not supported because the USB library only supports a single instance of a USB hub. The application-level interface to the USB hub class consists of only an initialization function and requires no additional application-level changes to handle any of the supported USB classes. When USB hub support is enabled, non-hub devices can still be directly connected to the USB controller with no special handling by the application. The next section covers the application interfaces to the USB hub class and the memory requirements when enabling the USB hub support.

Device Interface

The application layer of the USB hub class driver provides functions that an application uses to configure or disable the USB hub class driver. To initialize the USB hub class driver, the application must call USBHHubOpen() and provide it with a memory pool suitable to hold the configuration descriptors of the maximum number of attached devices and a hub instance structure. The memory pool allocation is very similar to how an application provides memory to the USBHCDInit() function with the exception that that the amount of memory should be multiplied by the number of devices supported. This memory pool size should be the expected maximum configuration descriptor size multiplied by **MAX_USB_DEVICES**. The application also provides a tHubInstance structure that holds private instance data that should not be accessed by the application. In order to release an instance of a hub class driver, the application must call USBHHubClose(). This call to USBHHubClose() is only made if the application is shutting down the USB interface.
Example: USB Hub with Keyboard and MSC support.

```
//*****************************************************************************
//
// The size of the host controller's memory pool in bytes.
//
//*****************************************************************************
#define HCD_MEMORY_SIZE         128

//*****************************************************************************
//
// The memory pool to provide to the Host controller driver.
//
//*****************************************************************************
uint8_t g_pui8HCDPool[HCD_MEMORY_SIZE];

//*****************************************************************************
//
// The size of the host controller's memory pool in bytes.
//
//*****************************************************************************
#define HUB_POOL_SIZE           (HCD_MEMORY_SIZE * MAX_USB_DEVICES)

//*****************************************************************************
//
// The memory pool to provide to the hub driver.  This pool is used to hold the
// configuration descriptors of the devices attached to the hub.  It must be
// sized to be at least
// (MAX_USB_DEVICES * (largest expected configuration descriptor)) bytes.
//
//*****************************************************************************
uint8_t g_pui8HubPool[HUB_POOL_SIZE];

//*****************************************************************************
//
// The instance data for the hub, which is internal data and should not be
// accessed by the application.
//
//*****************************************************************************
tHubInstance g_sHubInstance;

//*****************************************************************************
//
// The global that holds all of the host drivers in use in the application.
// In this case, the Mass Storage, HID, and Hub class drivers are present.
//
//*****************************************************************************
static tUSBHostClassDriver const * const g_ppsHostClassDrivers[] =
{
    &g_sUSBHostMSCClassDriver,
```

```
    &g_sUSBHIDClassDriver,
    &g_sUSBHubClassDriver,
    &g_sUSBEventDriver
};

//*****************************************************************************
//
// The global that holds the number of class drivers in the
// g_ppsHostClassDrivers list.
//
//*****************************************************************************
static const uint32_t g_ui32NumHostClassDrivers =
    sizeof(g_ppsHostClassDrivers) / sizeof(tUSBHostClassDriver *);

//
// Initialize the USB stack mode to host.
//
USBStackModeSet(0, USB_MODE_HOST, 0);

//
// Register the host class drivers.
//
USBHCDRegisterDrivers(0, g_ppsHostClassDrivers, g_ui32NumHostClassDrivers);

//
// Open the Keyboard and Mass storage interfaces.
//
KeyboardOpen();
MSCOpen();

//
// Open a hub instance and provide it with the memory required to hold
// configuration descriptors for each attached device and the private hub
// instance data.
//
USBHHubOpen(HubCallback);

//
// Initialize the power configuration by configuring the power enable signal
// to be active high and not enabling the power fault.
//
USBHCDPowerConfigInit(0, USBHCD_VBUS_AUTO_HIGH | USBHCD_VBUS_FILTER);

//
// Initialize the USB controller with a 2ms polling rate.
//
HCDInit(0, g_pui8HCDPool, HCD_MEMORY_SIZE);

while(1)
{
    HCDMain();
}
```

3.4.3 HID Class Driver

The HID class driver provides access to any type of HID class by leaving the details of the HID device to the layer above the HID class driver. The top layer of the HID class driver provides common functions to open or close an instance of a HID device, read a device's report descriptor so that it can be parsed by the HID device code, and get and set reports on a HID device. The lower level interface that is connected to the host controller driver is specified in the g_USBHIDClassDriver structure. This structure is used to register the HID class driver with the host class driver so that it is called when a HID device is connected and enumerated. The functions in the g_USBHIDClassDriver structure should never be

called directly by and application or a host class driver as they are reserved for access by the host controller driver.
In the following example the generic HID class driver is registered with the USB host controller driver and then a call is made to open an instance of a mouse class device. Typically the call to USBHHIDOpen() is made from within a device class interface while the USBHCDRegisterDrivers() call is made from the main application. For instance the USBHHIDOpen() for the mouse device provided with the USB library is made in the USBHMouseOpen() function which is part of the USB mouse interface.

Device Interface

At the top layer of the HID class driver, the driver has a device class interface for used by various HID devices. In order for the HID class driver to recognize a device, the device class is responsible for calling the USBHHIDOpen(). This call specifies the type of device and a callback for this device type so that any events related to this device type can be passed back to the device class driver. The defined classes are in the type defined values in the tHIDSubClassProtocol type and are passed into the USBHHIDOpen() call via the eDeviceType parameter. In order to release an instance of a HID class driver, the HID device class or application must call the USBHHIDClose() to allow a new or different type of device to be connected. In the examples provided in the USB library the report descriptors are retrieved but are not used as the examples rely on the "boot" mode of the USB keyboard and mouse to fix the format of the report descriptors. This is accomplished by using the USBHHIDSetReport() interface to force the device into its boot protocol mode. As this could be limiting or not available in other types of applications or devices, the USBHHIDGetReportDescriptor() provides the ability of a generic HID device to query the device for its report descriptor(s). The last two remaining HID interfaces, USBHHIDSetReport() and USBHHIDGetReport(), provide access to the HID reports.
Example: Adding HID Class Driver

```
const tUSBHostClassDriver * const g_ppsUSBHostClassDrivers[] =
{
    &g_USBHIDClassDriver
};

//
// Register the host class drivers.
//
USBHCDRegisterDrivers(0, g_ppsUSBHostClassDrivers, 1);

...

//
// Open an instance of a HID mouse class driver.
//
psMouseInstance = USBHHIDOpen(USBH_HID_DEV_MOUSE,
                              USBHMouseCallback,
                              (void *)&g_sUSBHMouse);
```

Once a HID device has been opened the first callback it receives is a USB_EVENT_CONNECTED event, indicating that a HID device of the type passed into the USBHHIDOpen() has been connected and the USB library host controller driver has completed enumeration of the device. When the HID device has been removed a USB_EVENT_DISCONNECTED event occurs. When shutting down or to release a device, the application should call USBHHIDClose() to disable callbacks. This does not actually power down the device but it stops the driver from calling the application. During normal operation the host class driver receives USB_EVENT_SCHEDULER and USB_EVENT_RX_AVAILABLE events. The USB_EVENT_SCHEDULER indicates that

the HID class driver should schedule a new request if it is ready to do so. This done by calling USBJHCDPipeSchedule() to request that a new IN request is made on the given Interrupt IN pipe. When the USB_EVENT_RX_AVAILABLE occurs this indicates that new data is available due to completion of the previous request for data on the Interrupt IN pipe. The USB_EVENT_RX_AVAILABLE is passed on the device class interface to allow it to request the data via a call to USBHHIDGetReport(). It is up to the device class driver to interpret the data in the report structure that is returned. In some cases, like the keyboard example, the device class may also need to call the host class driver to issue a set report to send data to the device. This is done by calling the USBHHIDSetReport() interface of the host class driver. This sends data to the device by using the correct USB OUT pipe.

3.4.4 Mass Storage Class Driver

The mass storage host class driver provides access to devices that support the mass storage class protocol. The most common of these devices are USB flash drives. This host class driver provides a simple block based interface to the devices that can be matched up with an application's file system. A USB host class driver for mass storage devices is included with the USB library. It provides a simple block based interface that can be used with an application's file system as it provides direct block interface to mass storage devices based on logical block address.

The mass storage host class driver provides an application API for access to USB flash drives. The API provided is meant to match with file systems that need block based read/write access to flash drives. The USBHMSCBlockRead() and USBHMSCBlockWrite() functions provide the block read and block write device access. These function performs block operations at the size specified by the flash drive. Since some flash drives require some setup time after enumeration before they are ready for drive access, the mass storage class driver provides the USBHMSCDriveReady() function to check if the drive is ready for normal operation.

The mass storage host class driver also provides an interface to the USB library host controller driver to complete enumeration of mass storage class devices. The mass storage class driver information is held in the global structure g_USBMSCClassDriver. This structure should only be referenced by the application and the function pointers in this structure should never called directly by anything other than the host controller driver. The USBHMSCOpen() and USBHMSCClose() provide the interface for the host controller's enumeration code to call when a mass storage class device is detected or removed. It is up to the mass storage host class driver to provide a callback to the file system or application for notification of the drive being removed or added. To make the the mass storage class driver visible to the host controller driver it must be added in the list of drivers provided in the USBHCDRegisterDrivers() function call. The class enumeration constant is set to USB_CLASS_MASS_STORAGE so any devices enumerating with value loads this class driver.

Device Interface

This next section covers how an application or file system interacts with the host mass storage class driver provided with the USB library. The application or file system must register the mass storage class driver with a call to USBHCDRegisterDrivers() with the g_USBHostMSCClassDriver as a member of the array passed in to the call. Once the host mass storage class driver has been registered, the application must call USBHMSCDriveOpen() to allow the application or file system to be called when a new mass storage device is connected or disconnected or any other mass storage class event occurs.

Example: Adding Mass Storage Class Driver

```
const tUSBHostClassDriver * const g_ppsUSBHostClassDrivers[] =
{
    &g_sUSBHostMSCClassDriver
};

//
// Register the host class drivers.
//
USBHCDRegisterDrivers(0, g_ppsUSBHostClassDrivers, 1);

//
// Initialize the mass storage class driver on controller 0 with the
// MSCCallback() function as the callback for events.
//
USBHMSCDriveOpen(0, MSCCallback);
```

The first callback is a USB_EVENT_CONNECTED event, indicating that a mass storage class flash drive was inserted and the USB library host stack has completed enumeration of the device. This does not indicate that the flash drive is ready for read/write operations but that is has been detected. The USBHMSCDriveReady() function should be called to determine when the flash drive is ready for read/write operations. When the device has been removed an USB_EVENT_DISCONNECTED event occurs. When shutting down, the application should call USBHMSCDriveClose() to disable callbacks. This does not actually power down the mass storage device but it stops the driver from calling the application.
Once the USBHMSCDriveReady() call indicates that the flash drive is ready, the application can use the USBHMSCBlockRead() and USBHMSCBlockWrite() functions to access the device. These are block based functions that use the logical block address to indicate which block to access. It is important to note that the size passed in to these functions is in blocks and not bytes and that the most common block size is 512 bytes. These calls always read or write a full block so space must be allocated appropriately. The following example shows calls for both reading and writing blocks from the mass storage class device.
Example: Block Read/Write Calls

```
//
// Read 1 block starting at logical block 0.
//
USBHMSCBlockRead(ui32MSCDevice, 0, pui8Buffer, 1);

//
// Write 2 blocks starting at logical block 500.
//
USBHMSCBlockWrite(ui32MSCDevice, 500, pui8Buffer, 2);
```

SCSI Functions

Since most mass storage class device adhere to the SCSI protocol for block based calls, the USB library provides SCSI functions for the mass storage class driver to communicate with flash drives. The commands and data pass over the USB pipes provided by the host controller driver. The only types of mass storage class devices that are supported are devices that use the SCSI protocol. Since flash drives only support a limited subset of the SCSI protocol, only the SCSI functions needed by mass storage class to mount and access flash drives are implemented. The SCSIRead10() and SCSIWrite10() functions are the two functions used for reading and writing to the mass storage class devices. The remaining SCSI functions are used to get information about the mass storage devices like the size of the blocks on the device and the number of blocks present. Others are used for error handling or testing if the device is ready for a new command.

3.4.5 Audio Class Driver

The USB audio host class driver provides access to devices that support the USB audio class protocol. This driver provides access to both audio in and audio out interfaces. The application opens an instance of the audio device by calling USBHostAudioOpen() and providing a callback function to receive events notifications when an audio device has been enumerated and is ready for normal operation(USBH_AUDIO_EVENT_OPEN), or when an active audio device has been disconnected(USBH_AUDIO_EVENT_CLOSE). The application should not access any other APIs that use the interface returned from the USBHostAudioOpen() function until an USBH_AUDIO_EVENT_OPEN event is received and not after a USBH_AUDIO_EVENT_CLOSE event is received. When the application no longer needs the audio interface it can call USBHostAudioClose() to stop the audio device and no longer be notified of changes to the audio device. Audio output is handled by providing buffers to the host audio driver by calling USBHostAudioPlay() and including a callback function for the buffer. The buffers are returned to the application by the callback to the application provided in the USBHostAudioPlay(). This allows the application to gain control while the audio is being scheduled for output. The audio input is handled by providing buffers to the host audio driver by calling USBHostAudioRecord() and passing in a buffer callback as well. Buffers are then scheduled to be filled by the USB controller and returned to the application by the callback function that the application provided in the USBHostAudioRecord() call. The next section provides more detail and examples for each application level API.

Application Interface

The USB host audio application interface provides a basic method for controlling audio output, input and some volume control. Since the USB host audio provides only a small amount of buffering, it is up to the application to provide adequate buffering based on it's other functions to keep the audio stream from starving for data.
The USB host audio driver requires some initial configuration by the application that is outside of the USB audio driver's control. The first of these is to enable the uDMA controller and configure a DMA control table that includes the USB DMA channels. The application must also register the USB host audio driver by calling USBHCDRegisterDrivers() with the g_USBHostAudioClassDriver structure pointer in the list of supported drivers. Finally the application must create an instance of the USB host audio device by calling the USBHostAudioOpen() function and provide it with a callback for basic USB audio events, saving the value returned for use with other APIs.
Example: Initial USB Audio Setup

```
//
// The instance data for the USB host audio driver.
//
uint32_t g_psAudioInstance = 0;

//
// The control table used by the uDMA controller.  This table must be aligned
// to a 1024 byte boundary.  When using USB with uDMA if it is only used for
// USB then only first 6 channels are needed.
//
// Note: If other DMA channels are used then the table must be large enough
// to hold all channels in use.
//
tDMAControlTable g_psDMAControlTable[6];

//
// The global that holds all of the host drivers in use in the application.
// In this case, only the host audio class is loaded.
```

```
//
static tUSBHostClassDriver const * const g_ppsHostClassDrivers[] =
{
    &g_sUSBHostAudioClassDriver,
    &g_sUSBEventDriver
};

    ...

    //
    // Enable the uDMA controller and set up the control table base.
    //
    SysCtlPeripheralEnable(SYSCTL_PERIPH_UDMA);
    uDMAEnable();
    uDMAControlBaseSet(g_psDMAControlTable);

    //
    // Register the host class drivers.
    //
    USBHCDRegisterDrivers(0, g_ppsHostClassDrivers, g_ui32NumHostClassDrivers);

    //
    // Open an instance of the mass storage class driver.
    //
    g_psAudioInstance = USBHostAudioOpen(0, AudioCallback);

    ...
```

Audio output is handled by setting the format of the audio stream and then by calling the USBHostAudioPlay() function to provide new buffers to the audio device. The callback function that is provided with this call returns the buffers when the driver is no longer using them. In order for audio output to start, the application must first set the audio format with a successful call to USBHostAudioFormatSet(). If the format was not supported by the audio device then this function returns a non-zero value and USBHostAudioPlay() should not be called until a valid format is selected. Once a valid format is set the application should provide audio data to the host audio driver by calling USBHostAudioPlay() and then always waiting for the callback to indicate that the buffer has been released. Calling the USBHostAudioPlay() function before the previous buffer has been released can cause the previous transfer to be interrupted or canceled. Since the USB host audio driver provides limited buffering it is up to the application to have data ready for output. The application can safely call USBHostAudioPlay() function directly from the callback function to provide a new buffer to the USB audio device.

Example: Audio Output

```
void AudioOutCallback(void *pvBuffer, uint32_t ui32Param, uint32_t ui32Event)
{
    //
    // Check if this was a buffer free event and provide a new buffer to the
    // host audio driver.
    //
    if(ui32Event == USB_EVENT_TX_COMPLETE)
    {
        USBHostAudioPlay(psAudioInstance, pNewBuffer, ui32Size,
                         AudioOutCallback));
    }

}

void AudioPlay(void)
{
    //
    // Wait for USBH_AUDIO_EVENT_OPEN event.
    //
```

```
    ...

    //
    // Set the audio format to 48KHz 16 bit stereo output.
    //
    USBHostAudioFormatSet(psAudioInstance, 48000, 16, 2,
                          USBH_AUDIO_FORMAT_OUT);

    ...

    //
    // Start the output of the first buffer and let the callback start the
    // remaining buffers.
    //
    USBHostAudioPlay(psAudioInstance, pBuffer, ui32Size, AudioOutCallback));

    //
    // Handle filling returned buffers.
    //

    ...
}
```

Audio input is handled by setting the format of the audio stream and then by calling the USBHostAudioRecord() function to provide a new buffer to be filled by the host audio driver. The callback function that is provided with this call returns the buffer when the audio driver has new data available. In order for audio input to start, the application must first set the audio input format with a successful call to USBHostAudioFormatSet(). If the format was not supported by the audio device then this function returns a non-zero value. USBHostAudioRecord() should not be called until a valid format is selected. Once a valid format is set the application should provide an audio buffer to the host audio driver by calling USBHostAudioRecord() and wait for the callback to indicate that the buffer has been filled. Calling the USBHostAudioRecord() function before the previous buffer has been filled can cause the previous input transfer to be interrupted or lost. Since the USB host audio driver provides limited buffering it is up to the application to handle the input buffers and provide new buffers. The application can safely call USBHostAudioRecord() function directly from the callback function to provide a new buffer to the USB audio device, however the same buffer should not be passed back until it has been processed or the host audio driver may overwrite the data.

Example: Audio Input

```
void AudioInCallback(tUSBHostAudioInstance *psAudioInstance, uint32_t ui32Event,
                     uint32_t ui32Param, void *pvMsgData)
{
    //
    // Check if this was a buffer full event and provide a new buffer to the
    // host audio driver.
    //
    if(ui32Event == USB_EVENT_RX_AVAILABLE)
    {
        USBHostAudioRecord(psAudioInstance, pNewBuffer, ui32Size,
                           AudioInCallback));
    }

}

void AudioRecord(void)
{
    //
    // Wait for USBH_AUDIO_EVENT_OPEN event.
    //

    ...
```

```
    //
    // Set the audio format to 48KHz 16 bit stereo output.
    //
    USBHostAudioFormatSet(psAudioInstance, 48000, 16, 2,
                          USBH_AUDIO_FORMAT_IN);

    ...

    //
    // Start the input of the first buffer and let the callback start the
    // remaining buffers.
    //
    USBHostAudioRecord(psAudioInstance, pBuffer, ui32Size, AudioInCallback));

    //
    // Handle filling returned buffers.
    //

    ...
}
```

3.4.6 Implementing Custom Host Class Drivers

This next section covers how to implement a custom host class driver and how the host controller driver finds the driver. All host class drivers must provide their own driver interface that is visible to the host controller driver. As with the host class drivers that are included with the USB library, this means exposing a driver interface of the type tUSBClassDriver. In the example below the USBGenericOpen() function is called when the host controller driver enumerates a device that matches the “USB_CLASS_SOMECLASS” interface class. The USBGenericClose() function is called when the device of this class is removed. The following example shows a definition of a custom host class driver.

Example: Custom Host Class Driver Interface

```
tUSBClassDriver sUSBGenericClassDriver =
{
    USB_CLASS_SOMECLASS,
    USBGenericOpen,
    USBGenericClose,
    USBGenericIntHandler
};
```

The *ulInterfaceClass* member of the tUSBClassDriver structure is the class read from the device’s interface descriptor during enumeration. This number is used to as the primary search value for a host class driver. If a device is connected that matches this structure member then that host class driver is loaded. The *pfnOpen* member of the tUSBClassDriver structure is called when a device with a matching interface class is detected. This function should do whatever is necessary to handle device detection and initial configuration of the device, this includes allocating any USB pipes that the device may need for communications. This requires parsing the endpoint descriptors for a device’s endpoints and then allocating the USB pipes based on the types and number of endpoints discover. The host class drivers provided with the USB library demonstrate how to parse and allocate USB pipes. This call is not at made interrupt level so it can be interrupted by other USB events. Anything that must be done immediately before any other communications with the device should be done in the *pfnOpen* function. The *pfnOpen* member should should return a handle that is passed to the remaining functions *pfnClose* and *pfnIntHandler*. This handle should enable the host class driver to differentiate between different instances of the same type of device. The value returned can be any value as the USB library simply returns it unmodified to the other host class driver functions. The *pfnClose* structure member

is called when the device that was created with *pfnOpen* call is removed from the system. All driver clean up should be done in the *pfnClose* call as no more calls are made to the host class driver. If the host class driver needs to respond to USB interrupts, an optional *pfnIntHandler* function pointer is provided. This function runs at interrupt time and called for any interrupt that occurs due to this device or for generic USB events. This function is not required and should only be implemented if it is necessary. It is completely up to the custom USB host class driver to determine it's own upper layer interface to applications or to other device interface layers. With the addition of hub support, the application interface layer should take into account multiple instances of a device class if multiple instances of devices are supported.

3.5 Host Class Driver Definitions

Defines

- #define USBH_AUDIO_EVENT_CLOSE
- #define USBH_AUDIO_EVENT_OPEN
- #define USBH_EVENT_HID_KB_MOD
- #define USBH_EVENT_HID_KB_PRESS
- #define USBH_EVENT_HID_KB_REL
- #define USBH_EVENT_HID_MS_PRESS
- #define USBH_EVENT_HID_MS_REL
- #define USBH_EVENT_HID_MS_X
- #define USBH_EVENT_HID_MS_Y

Enumerations

- enum tHIDSubClassProtocol { eUSBHHIDClassNone, eUSBHHIDClassKeyboard, eUSBHHIDClassMouse, eUSBHHIDClassVendor }

Functions

- void USBHHIDClose (tHIDInstance *psHIDInstance)
- uint32_t USBHHIDGetReport (tHIDInstance *psHIDInstance, uint32_t ui32Interface, uint8_t *pui8Data, uint32_t ui32Size)
- uint32_t USBHHIDGetReportDescriptor (tHIDInstance *psHIDInstance, uint8_t *pui8Buffer, uint32_t ui32Size)
- tHIDInstance * USBHHIDOpen (tHIDSubClassProtocol iDeviceType, tUSBCallback pfnCallback, void *pvCBData)
- uint32_t USBHHIDSetIdle (tHIDInstance *psHIDInstance, uint8_t ui8Duration, uint8_t ui8ReportID)
- uint32_t USBHHIDSetProtocol (tHIDInstance *psHIDInstance, uint32_t ui32BootProtocol)
- uint32_t USBHHIDSetReport (tHIDInstance *psHIDInstance, uint32_t ui32Interface, uint8_t *pui8Data, uint32_t ui32Size)
- void USBHHubClose (tHubInstance *psHubInstance)
- void USBHHubEnumerationComplete (uint8_t ui8Hub, uint8_t ui8Port)
- void USBHHubEnumerationError (uint8_t ui8Hub, uint8_t ui8Port)
- tHubInstance * USBHHubOpen (tUSBHHubCallback pfnCallback)

- int32_t USBHMSCBlockRead (tUSBHMSCInstance *psMSCInstance, uint32_t ui32LBA, uint8_t *pui8Data, uint32_t ui32NumBlocks)
- int32_t USBHMSCBlockWrite (tUSBHMSCInstance *psMSCInstance, uint32_t ui32LBA, uint8_t *pui8Data, uint32_t ui32NumBlocks)
- void USBHMSCDriveClose (tUSBHMSCInstance *psMSCInstance)
- tUSBHMSCInstance * USBHMSCDriveOpen (uint32_t ui32Drive, tUSBHMSCCallback pfnCallback)
- int32_t USBHMSCDriveReady (tUSBHMSCInstance *psMSCInstance)
- void USBHostAudioClose (tUSBHostAudioInstance *psAudioInstance)
- uint32_t USBHostAudioFormatGet (tUSBHostAudioInstance *psAudioInstance, uint32_t ui32SampleRate, uint32_t ui32Bits, uint32_t ui32Channels, uint32_t ui32Flags)
- uint32_t USBHostAudioFormatSet (tUSBHostAudioInstance *psAudioInstance, uint32_t ui32SampleRate, uint32_t ui32Bits, uint32_t ui32Channels, uint32_t ui32Flags)
- tUSBHostAudioInstance * USBHostAudioOpen (uint32_t ui32Index, tUSBHostAudioCallback pfnCallback)
- int32_t USBHostAudioPlay (tUSBHostAudioInstance *psAudioInstance, void *pvBuffer, uint32_t ui32Size, tUSBHostAudioCallback pfnCallback)
- int32_t USBHostAudioRecord (tUSBHostAudioInstance *psAudioInstance, void *pvBuffer, uint32_t ui32Size, tUSBHostAudioCallback pfnCallback)
- uint32_t USBHostAudioVolumeGet (tUSBHostAudioInstance *psAudioInstance, uint32_t ui32Interface, uint32_t ui32Channel)
- uint32_t USBHostAudioVolumeMaxGet (tUSBHostAudioInstance *psAudioInstance, uint32_t ui32Interface, uint32_t ui32Channel)
- uint32_t USBHostAudioVolumeMinGet (tUSBHostAudioInstance *psAudioInstance, uint32_t ui32Interface, uint32_t ui32Channel)
- uint32_t USBHostAudioVolumeResGet (tUSBHostAudioInstance *psAudioInstance, uint32_t ui32Interface, uint32_t ui32Channel)
- void USBHostAudioVolumeSet (tUSBHostAudioInstance *psAudioInstance, uint32_t ui32Interface, uint32_t ui32Channel, uint32_t ui32Value)
- uint32_t USBHSCSIInquiry (uint32_t ui32InPipe, uint32_t ui32OutPipe, uint8_t *pui8Data, uint32_t *pui32Size)
- uint32_t USBHSCSIModeSense6 (uint32_t ui32InPipe, uint32_t ui32OutPipe, uint32_t ui32Flags, uint8_t *pui8Data, uint32_t *pui32Size)
- uint32_t USBHSCSIRead10 (uint32_t ui32InPipe, uint32_t ui32OutPipe, uint32_t ui32LBA, uint8_t *pui8Data, uint32_t *pui32Size, uint32_t ui32NumBlocks)
- uint32_t USBHSCSIReadCapacities (uint32_t ui32InPipe, uint32_t ui32OutPipe, uint8_t *pui8Data, uint32_t *pui32Size)
- uint32_t USBHSCSIReadCapacity (uint32_t ui32InPipe, uint32_t ui32OutPipe, uint8_t *pui8Data, uint32_t *pui32Size)
- uint32_t USBHSCSIRequestSense (uint32_t ui32InPipe, uint32_t ui32OutPipe, uint8_t *pui8Data, uint32_t *pui32Size)
- uint32_t USBHSCSITestUnitReady (uint32_t ui32InPipe, uint32_t ui32OutPipe)
- uint32_t USBHSCSIWrite10 (uint32_t ui32InPipe, uint32_t ui32OutPipe, uint32_t ui32LBA, uint8_t *pui8Data, uint32_t *pui32Size, uint32_t ui32NumBlocks)

Variables

- const tUSBHostClassDriver g_sUSBHIDClassDriver
- const tUSBHostClassDriver g_sUSBHostAudioClassDriver
- const tUSBHostClassDriver g_sUSBHostMSCClassDriver

- const tUSBHostClassDriver g_sUSBHubClassDriver

3.5.1 Detailed Description

The macros and functions defined in this section can be found in header files `include/host/usbhhid.h`, `include/host/usbhmsc.h` and `include/host/usbhscsi.h`.

3.5.2 Define Documentation

3.5.2.1 #define USBH_AUDIO_EVENT_CLOSE

This USB host audio event indicates that the previously connected device has been disconnected. The *pvBuffer* and *ui32Param* values are not used in this event.

3.5.2.2 #define USBH_AUDIO_EVENT_OPEN

This USB host audio event indicates that the device is connected and ready to send or receive buffers. The *pvBuffer* and *ui32Param* values are not used in this event.

3.5.2.3 #define USBH_EVENT_HID_KB_MOD

The HID keyboard detected one of the keyboard modifiers being pressed.

3.5.2.4 #define USBH_EVENT_HID_KB_PRESS

The HID keyboard detected a key being pressed.

3.5.2.5 #define USBH_EVENT_HID_KB_REL

The HID keyboard detected a key being released.

3.5.2.6 #define USBH_EVENT_HID_MS_PRESS

A button was pressed on a HID mouse.

3.5.2.7 #define USBH_EVENT_HID_MS_REL

A button was released on a HID mouse.

3.5.2.8 #define USBH_EVENT_HID_MS_X

The HID mouse detected movement in the X direction.

3.5.2.9 #define USBH_EVENT_HID_MS_Y

The HID mouse detected movement in the Y direction.

3.5.3 Enumeration Type Documentation

3.5.3.1 enum tHIDSubClassProtocol

The following values are used to register callbacks to the USB HOST HID device class layer.

Enumerator:

eUSBHHIDClassNone No device should be used. This value should not be used by applications.

eUSBHHIDClassKeyboard This is a keyboard device.

eUSBHHIDClassMouse This is a mouse device.

eUSBHHIDClassVendor This is a vendor specific device.

3.5.4 Function Documentation

3.5.4.1 void USBHHIDClose (tHIDInstance * *psHIDInstance*)

This function is used to release an instance of a HID device.

Parameters:

psHIDInstance is the instance value for a HID device to release.

This function releases an instance of a HID device that was created by a call to USBHHIDOpen(). This call is required to allow other HID devices to be enumerated after another HID device has been disconnected. The *psHIDInstance* parameter should hold the value that was returned from the previous call to USBHHIDOpen().

Returns:

None.

3.5.4.2 uint32_t USBHHIDGetReport (tHIDInstance * *psHIDInstance*, uint32_t *ui32Interface*, uint8_t * *pui8Data*, uint32_t *ui32Size*)

This function is used to retrieve a report from a HID device.

Parameters:

psHIDInstance is the value that was returned from the call to USBHHIDOpen().

ui32Interface is the interface to retrieve the report from.

pui8Data is the memory buffer to use to store the report.

ui32Size is the size in bytes of the buffer pointed to by *pui8Buffer*.

This function is used to retrieve a report from a USB pipe. It is usually called when the USB HID layer has detected a new data available in a USB pipe. The USB HID host device code will receive a **USB_EVENT_RX_AVAILABLE** event when data is available, allowing the callback function to retrieve the data.

Returns:

Returns the number of bytes read from report.

3.5.4.3 uint32_t USBHHIDGetReportDescriptor (tHIDInstance * *psHIDInstance*, uint8_t * *pui8Buffer*, uint32_t *ui32Size*)

This function can be used to retrieve the report descriptor for a given device instance.

Parameters:

psHIDInstance is the value that was returned from the call to USBHHIDOpen().

pui8Buffer is the memory buffer to use to store the report descriptor.

ui32Size is the size in bytes of the buffer pointed to by *pui8Buffer*.

This function is used to return a report descriptor from a HID device instance so that it can determine how to interpret reports that are returned from the device indicated by the *psHIDInstance* parameter. This call is blocking and will return the number of bytes read into the *pui8Buffer*.

Returns:

Returns the number of bytes read into the *pui8Buffer*.

3.5.4.4 tHIDInstance* USBHHIDOpen (tHIDSubClassProtocol *iDeviceType*, tUSBCallback *pfnCallback*, void * *pvCBData*)

This function is used to open an instance of a HID device.

Parameters:

iDeviceType is the type of device that should be loaded for this instance of the HID device.

pfnCallback is the function that will be called whenever changes are detected for this device.

pvCBData is the data that will be returned in when the *pfnCallback* function is called.

This function creates an instance of an specific type of HID device. The *iDeviceType* parameter is one subclass/protocol values of the types specified in enumerated types tHIDSubClassProtocol. Only devices that enumerate with this type will be called back via the *pfnCallback* function. The *pfnCallback* parameter is the callback function for any events that occur for this device type. The *pfnCallback* function must point to a valid function of type *tUSBCallback* for this call to complete successfully. To release this device instance the caller of USBHHIDOpen() should call USBHHIDClose() and pass in the value returned from the USBHHIDOpen() call.

Returns:

This function returns and instance value that should be used with any other APIs that require an instance value. If a value of 0 is returned then the device instance could not be created.

3.5.4.5 uint32_t USBHHIDSetIdle (tHIDInstance * *psHIDInstance*, uint8_t *ui8Duration*, uint8_t *ui8ReportID*)

This function is used to set the idle timeout for a HID device.

Parameters:

psHIDInstance is the value that was returned from the call to USBHHIDOpen().

ui8Duration is the duration of the timeout in milliseconds.

ui8ReportID is the report identifier to set the timeout on.

This function will send the Set Idle command to a HID device to set the idle timeout for a given report. The length of the timeout is specified by the *ui8Duration* parameter and the report the timeout for is in the *ui8ReportID* value.

Returns:

Always returns 0.

3.5.4.6 uint32_t USBHHIDSetProtocol (tHIDInstance * *psHIDInstance*, uint32_t *ui32BootProtocol*)

This function is used to set or clear the boot protocol state of a device.

Parameters:

psHIDInstance is the value that was returned from the call to USBHHIDOpen().

ui32BootProtocol is either zero or non-zero to indicate which protocol to use for the device.

A USB host device can use this function to set the protocol for a connected HID device. This is commonly used to set keyboards and mice into their simplified boot protocol modes to fix the report structure to a know state.

Returns:

This function returns 0.

3.5.4.7 uint32_t USBHHIDSetReport (tHIDInstance * *psHIDInstance*, uint32_t *ui32Interface*, uint8_t * *pui8Data*, uint32_t *ui32Size*)

This function is used to send a report to a HID device.

Parameters:

psHIDInstance is the value that was returned from the call to USBHHIDOpen().

ui32Interface is the interface to send the report to.

pui8Data is the memory buffer to use to store the report.

ui32Size is the size in bytes of the buffer pointed to by *pui8Buffer*.

This function is used to send a report to a USB HID device. It can be only be called from outside the callback context as this function will not return from the call until the data has been sent successfully.

Returns:

Returns the number of bytes sent to the device.

3.5.4.8 void USBHHubClose (tHubInstance * *psHubInstance*)

This function is used to release a hub device instance.

Parameters:

psHubInstance is the hub device instance that is to be released.

This function is called when an instance of the hub device must be released. This function is typically made in preparation for shutdown or a switch to function as a USB device when in OTG mode. Following this call, the hub device is no longer available, but it can be opened again using a call to USBHHubOpen(). After calling USBHHubClose(), the host hub driver no longer provides any callbacks or accepts calls to other hub driver APIs.

Returns:

None.

3.5.4.9 void USBHHubEnumerationComplete (uint8_t *ui8Hub*, uint8_t *ui8Port*)

Informs the hub class driver that a downstream device has been enumerated.

Parameters:

ui8Hub is the address of the hub to which the downstream device is attached.

ui8Port is the port on the hub to which the downstream device is attached.

This function is called by the host controller driver to inform the hub class driver that a downstream device has been enumerated successfully. The hub driver then moves on and continues enumeration of any other newly connected devices.

Returns:

None.

3.5.4.10 void USBHHubEnumerationError (uint8_t *ui8Hub*, uint8_t *ui8Port*)

Informs the hub class driver that a downstream device failed to enumerate.

Parameters:

ui8Hub is the address of the hub to which the downstream device is attached.

ui8Port is the port on the hub to which the downstream device is attached.

This function is called by the host controller driver to inform the hub class driver that an attempt to enumerate a downstream device has failed. The hub driver then cleans up and continues enumeration of any other newly connected devices.

Returns:

None.

3.5.4.11 tHubInstance* USBHHubOpen (tUSBHHubCallback *pfnCallback*)

This function is used to enable the host hub class driver before any devices are present.

Parameters:

pfnCallback is the driver call back for host hub events.

This function is called to open an instance of a host hub device and provides a valid callback function for host hub events in the *pfnCallback* parameter. This function must be called before the USB host code can successfully enumerate a hub device or any devices attached to the hub. The *pui8HubPool* is memory provided to the hub class to manage the devices that are connected to the hub. The *ui32PoolSize* is the number of bytes and should be at least 32 bytes per device including the hub device itself. A simple formula for providing memory to the hub class is **MAX_USB_DEVICES** * 32 bytes of data to allow for proper enumeration of connected devices. The value for **MAX_USB_DEVICES** is defined in the usblib.h file and controls the number of devices supported by the USB library. The *ui32NumHubs* parameter defaults to one and only one buffer of size tHubInstance is required to be passed in the *psHubInstance* parameter.

Note:

Changing the value of **MAX_USB_DEVICES** requires a rebuild of the USB library to have an effect on the library.

Returns:

This function returns the driver instance to use for the other host hub functions. If there is no instance available at the time of this call, this function returns zero.

3.5.4.12 int32_t USBHMSCBlockRead (tUSBHMSCInstance * *psMSCInstance*, uint32_t *ui32LBA*, uint8_t * *pui8Data*, uint32_t *ui32NumBlocks*)

This function performs a block read to an MSC device.

Parameters:

psMSCInstance is the device instance to use for this read.

ui32LBA is the logical block address to read on the device.

pui8Data is a pointer to the returned data buffer.

ui32NumBlocks is the number of blocks to read from the device.

This function will perform a block sized read from the device associated with the *psMSCInstance* parameter. The *ui32LBA* parameter specifies the logical block address to read on the device. This function will only perform *ui32NumBlocks* block sized reads. In most cases this is a read of 512 bytes of data. The **pui8Data* buffer should be at least *ui32NumBlocks* * 512 bytes in size.

Returns:

The function returns zero for success and any negative value indicates a failure.

3.5.4.13 int32_t USBHMSCBlockWrite (tUSBHMSCInstance * *psMSCInstance*, uint32_t *ui32LBA*, uint8_t * *pui8Data*, uint32_t *ui32NumBlocks*)

This function performs a block write to an MSC device.

Parameters:

psMSCInstance is the device instance to use for this write.

ui32LBA is the logical block address to write on the device.

pui8Data is a pointer to the data to write out.

ui32NumBlocks is the number of blocks to write to the device.

This function will perform a block sized write to the device associated with the *psMSCInstance* parameter. The *ui32LBA* parameter specifies the logical block address to write on the device. This function will only perform *ui32NumBlocks* block sized writes. In most cases this is a write of 512 bytes of data. The *pui8Data* buffer should contain at least *ui32NumBlocks* * 512 bytes in size to prevent unwanted data being written to the device.

Returns:

The function returns zero for success and any negative value indicates a failure.

3.5.4.14 void USBHMSCDriveClose (tUSBHMSCInstance * *psMSCInstance*)

This function should be called to release a drive instance.

Parameters:

psMSCInstance is the device instance that is to be released.

This function is called when an MSC drive is to be released in preparation for shutdown or a switch to USB device mode, for example. Following this call, the drive is available for other clients who may open it again using a call to USBHMSCDriveOpen().

Returns:

None.

3.5.4.15 tUSBHMSCInstance * USBHMSCDriveOpen (uint32_t *ui32Drive*, tUSBHMSCCallback *pfnCallback*)

This function should be called before any devices are present to enable the mass storage device class driver.

Parameters:

ui32Drive is the drive number to open.

pfnCallback is the driver callback for any mass storage events.

This function is called to open an instance of a mass storage device. It should be called before any devices are connected to allow for proper notification of drive connection and disconnection. The *ui32Drive* parameter is a zero based index of the drives present in the system. There are a constant number of drives, and this number should only be greater than 0 if there is a USB hub present in the system. The application should also provide the *pfnCallback* to be notified of mass storage related events like device enumeration and device removal.

Returns:

This function will return the driver instance to use for the other mass storage functions. If there is no driver available at the time of this call, this function will return zero.

3.5.4.16 int32_t USBHMSCDriveReady (tUSBHMSCInstance * *psMSCInstance*)

This function checks if a drive is ready to be accessed.

Parameters:

psMSCInstance is the device instance to use for this read.

This function checks if the current device is ready to be accessed. It uses the *psMSCInstance* parameter to determine which device to check and returns zero when the device is ready. Any non-zero return code indicates that the device was not ready.

Returns:

This function returns zero if the device is ready and it returns a other value if the device is not ready or if an error occurred.

3.5.4.17 void USBHostAudioClose (tUSBHostAudioInstance * *psAudioInstance*)

This function should be called to release an audio device instance.

Parameters:

psAudioInstance is the device instance that is to be released.

This function is called when a host audio device needs to be released. This could be in preparation for shutdown or a switch to USB device mode, for example. Following this call, the audio device is available and can be opened again using a call to USBHostAudioOpen(). After calling this function, the host audio driver will no longer provide any callbacks or accept calls to other audio driver APIs.

Returns:

None.

3.5.4.18 uint32_t USBHostAudioFormatGet (tUSBHostAudioInstance * *psAudioInstance*, uint32_t *ui32SampleRate*, uint32_t *ui32Bits*, uint32_t *ui32Channels*, uint32_t *ui32Flags*)

This function is called to determine if an audio format is supported by the connected USB Audio device.

Parameters:

psAudioInstance is the device instance for this call.

ui32SampleRate is the sample rate of the audio stream.

ui32Bits is the number of bits per sample in the audio stream.

ui32Channels is the number of channels in the audio stream.

ui32Flags is a set of flags to determine what type of interface to retrieve.

This function is called when an application needs to determine which audio formats are supported by a USB audio device that has been connected. The *psAudioInstance* value that is used with this call is the value that was returned from the USBHostAudioOpen() function. This call checks the USB audio device to determine if it can support the values provided in the *ui32SampleRate*, *ui32Bits*, and *ui32Channels* values. The *ui32Flags* currently only supports either the **USBH_AUDIO_FORMAT_IN** or **USBH_AUDIO_FORMAT_OUT** values that indicates if a request is for an audio input and an audio output. If the format is supported this function returns zero, and this function returns a non-zero value if the format is not supported. This function does not set the current output or input format.

Returns:

A value of zero indicates the supplied format is supported and a non-zero value indicates that the format is not supported.

3.5.4.19 uint32_t USBHostAudioFormatSet (tUSBHostAudioInstance * *psAudioInstance*, uint32_t *ui32SampleRate*, uint32_t *ui32Bits*, uint32_t *ui32Channels*, uint32_t *ui32Flags*)

This function is called to set the current sample rate on an audio interface.

Parameters:

psAudioInstance specifies the device instance for this call.

ui32SampleRate is the sample rate in Hz.

ui32Bits is the number of bits per sample.

ui32Channels is then number of audio channels.

ui32Flags is a set of flags that determine the access type.

This function is called when to set the current audio output or input format for a USB audio device. The *psAudioInstance* value that is used with this call is the value that was returned from the USBHostAudioOpen() function. The application can use this call to insure that the audio format is supported and set the format at the same time. If the application is just checking for supported rates, then it should call the USBHostAudioFormatGet().

Note:

This function must be called before attempting to send or receive audio with the USBHostAudioPlay() or USBHostAudioRecord() functions.

Returns:

A non-zero value indicates the supplied format is not supported and a zero value indicates that the format was supported and has been configured.

3.5.4.20 tUSBHostAudioInstance * USBHostAudioOpen (uint32_t *ui32Index*, tUSBHostAudioCallback *pfnCallback*)

This function should be called before any devices are present to enable the host audio class driver.

Parameters:

ui32Index is the audio device to open (currently only 0 is supported).

pfnCallback is the driver call back for host audio events.

This function is called to open an instance of a host audio device and should provide a valid callback function for host audio events in the *pfnCallback* parameter. This function must be called before the USB host code can successfully enumerate an audio device.

Returns:

This function returns the driver instance to use for the other host audio functions. If there is no instance available at the time of this call, this function returns zero.

3.5.4.21 int32_t USBHostAudioPlay (tUSBHostAudioInstance * *psAudioInstance*, void * *pvBuffer*, uint32_t *ui32Size*, tUSBHostAudioCallback *pfnCallback*)

This function is called to send an audio buffer to the USB audio device.

Parameters:

psAudioInstance specifies the device instance for this call.

pvBuffer is the audio buffer to send.

ui32Size is the size of the buffer in bytes.

pfnCallback is a pointer to a callback function that is called when the buffer can be used again.

This function is called when an application needs to schedule a new buffer for output to the USB audio device. Since this call schedules the transfer and returns immediately, the application should provide a *pfnCallback* function to be notified when the buffer can be used again by the application. The *pfnCallback* function provided is called with the *pvBuffer* parameter set to the *pvBuffer* provided by this call, the *ui32Param* can be ignored and the *ui32Event* parameter is **USB_EVENT_TX_COMPLETE**.

Returns:

This function returns the number of bytes that were scheduled to be sent. If this function returns zero then there was no USB audio device present or the request could not be satisfied at this time.

3.5.4.22 int32_t USBHostAudioRecord (tUSBHostAudioInstance * *psAudioInstance*, void * *pvBuffer*, uint32_t *ui32Size*, tUSBHostAudioCallback *pfnCallback*)

This function is called to provide an audio buffer to the USB audio device for audio input.

Parameters:

psAudioInstance specifies the device instance for this call.

pvBuffer is the audio buffer to send.

ui32Size is the size of the buffer in bytes.

pfnCallback is a pointer to a callback function that is called when the buffer has been filled.

This function is called when an application needs to schedule a new buffer for input from the USB audio device. Since this call schedules the transfer and returns immediately, the application should provide a *pfnCallback* function to be notified when the buffer has been filled with audio data. When the *pfnCallback* function is called, the *pvBuffer* parameter is set to *pvBuffer* provided in this call, the *ui32Param* is the number of valid bytes in the pvBuffer and the *ui32Event* is set to **USB_EVENT_RX_AVAILABLE**.

Returns:

This function returns the number of bytes that were scheduled to be sent. If this function returns zero then there was no USB audio device present or the device does not support audio input.

3.5.4.23 uint32_t USBHostAudioVolumeGet (tUSBHostAudioInstance * *psAudioInstance*, uint32_t *ui32Interface*, uint32_t *ui32Channel*)

This function is used to get the current volume setting for a given audio device.

Parameters:

psAudioInstance is an instance of the USB audio device.

ui32Interface is the interface number to use to query the current volume setting.

ui32Channel is the 0 based channel number to query.

The function is used to retrieve the current volume setting for an audio device on the channel specified by *ui32Channel*. The *ui32Interface* is ignored for now and should be set to 0 to access the default audio control interface. The *ui32Channel* value starts with 0 which is the master audio volume control interface. The remaining *ui32Channel* values provide access to various other audio channels, with 1 and 2 being left and right audio channels.

Note:

On devices that do not support volume control interfaces, this call returns 0, indicating a 0db setting.

Returns:

Returns the current volume setting for the requested interface.

3.5.4.24 uint32_t USBHostAudioVolumeMaxGet (tUSBHostAudioInstance * *psAudioInstance*, uint32_t *ui32Interface*, uint32_t *ui32Channel*)

This function is used to get the maximum volume setting for a given audio device.

Parameters:

psAudioInstance is an instance of the USB audio device.

ui32Interface is the interface number to use to query the maximum volume control value.

ui32Channel is the 0 based channel number to query.

The function is used to retrieve the maximum volume setting for an audio device on the channel specified by *ui32Channel*. The *ui32Interface* is ignored for now and should be set to 0 to access the default audio control interface. The *ui32Channel* value starts with 0 which is the master audio volume control interface. The remaining *ui32Channel* values provide access to various other audio channels, with 1 and 2 being left and right audio channels.

Note:

On devices that do not support volume control interfaces, this call returns 0, indicating a 0db setting.

Returns:

Returns the maximum volume setting for the requested interface.

3.5.4.25 uint32_t USBHostAudioVolumeMinGet (tUSBHostAudioInstance * *psAudioInstance*, uint32_t *ui32Interface*, uint32_t *ui32Channel*)

This function is used to get the minimum volume setting for a given audio device.

Parameters:

psAudioInstance is an instance of the USB audio device.

ui32Interface is the interface number to use to query the minimum volume control value.

ui32Channel is the 0 based channel number to query.

The function is used to retrieve the minimum volume setting for an audio device on the channel specified by *ui32Channel*. The *ui32Interface* is ignored for now and should be set to 0 to access the default audio control interface. The *ui32Channel* value starts with 0 which is the master audio volume control interface. The remaining *ui32Channel* values provide access to various other audio channels, with 1 and 2 being left and right audio channels.

Note:

On devices that do not support volume control interfaces, this call returns 0, indicating a 0db setting.

Returns:

Returns the minimum volume setting for the requested interface.

3.5.4.26 uint32_t USBHostAudioVolumeResGet (tUSBHostAudioInstance * *psAudioInstance*, uint32_t *ui32Interface*, uint32_t *ui32Channel*)

This function is used to get the volume control resolution for a given audio device.

Parameters:

psAudioInstance is an instance of the USB audio device.

ui32Interface is the interface number to use to query the resolution for the volume control.

ui32Channel is the 0 based channel number to query.

The function is used to retrieve the volume control resolution for an audio device on the channel specified by *ui32Channel*. The *ui32Interface* is ignored for now and should be set to 0 to access the default audio control interface. The *ui32Channel* value starts with 0 which is the master audio volume control interface. The remaining *ui32Channel* values provide access to various other audio channels, with 1 and 2 being left and right audio channels.

Note:

On devices that do not support volume control interfaces, this call returns 0, indicating a 0db setting.

Returns:

Returns the volume control resolution for the requested interface.

3.5.4.27 void USBHostAudioVolumeSet (tUSBHostAudioInstance * *psAudioInstance*, uint32_t *ui32Interface*, uint32_t *ui32Channel*, uint32_t *ui32Value*)

This function is used to set the current volume setting for a given audio device.

Parameters:

psAudioInstance is an instance of the USB audio device.

ui32Interface is the interface number to use to set the current volume setting.

ui32Channel is the 0 based channel number to query.

ui32Value is the value to write to the USB audio device.

The function is used to set the current volume setting for an audio device on the channel specified by *ui32Channel*. The *ui32Interface* is ignored for now and should be set to 0 to access the default audio control interface. The *ui32Channel* value starts with 0 which is the master audio volume control interface. The remaining *ui32Channel* values provide access to various other audio channels, with 1 and 2 being left and right audio channels.

Note:

On devices that do not support volume control interfaces, this call returns 0, indicating a 0db setting.

Returns:

None.

3.5.4.28 uint32_t USBHSCSIInquiry (uint32_t *ui32InPipe*, uint32_t *ui32OutPipe*, uint8_t * *pui8Data*, uint32_t * *pui32Size*)

This will issue the SCSI inquiry command to a device.

Parameters:

ui32InPipe is the USB IN pipe to use for this command.

ui32OutPipe is the USB OUT pipe to use for this command.

pui8Data is the data buffer to return the results into.

pui32Size is the size of buffer that was passed in on entry and the number of bytes returned.

This function should be used to issue a SCSI Inquiry command to a mass storage device. To allow for multiple devices, the *ui32InPipe* and *ui32OutPipe* parameters indicate which USB pipes to use for this call.

Note:

The *pui8Data* buffer pointer should have at least **SCSI_INQUIRY_DATA_SZ** bytes of data or this function will overflow the buffer.

Returns:

This function returns the SCSI status from the command. The value will be either **SCSI_CMD_STATUS_PASS** or **SCSI_CMD_STATUS_FAIL**.

3.5.4.29 uint32_t USBHSCSIModeSense6 (uint32_t *ui32InPipe*, uint32_t *ui32OutPipe*, uint32_t *ui32Flags*, uint8_t * *pui8Data*, uint32_t * *pui32Size*)

This will issue the SCSI Mode Sense(6) command to a device.

Parameters:

ui32InPipe is the USB IN pipe to use for this command.

ui32OutPipe is the USB OUT pipe to use for this command.

ui32Flags is a combination of flags defining the exact query that is to be made.

pui8Data is the data buffer to return the results into.

pui32Size is the size of the buffer on entry and number of bytes read on exit.

This function should be used to issue a SCSI Mode Sense(6) command to a mass storage device. To allow for multiple devices, the *ui32InPipe* and *ui32OutPipe* parameters indicate which USB pipes to use for this call. The call will return at most the number of bytes in the *pui32Size* parameter, however it can return less and change the *pui32Size* parameter to the number of valid bytes in the **pui32Size* buffer.

The *ui32Flags* parameter is a combination of the following three sets of definitions:

One of the following values must be specified:

- **SCSI_MS_PC_CURRENT** request for current settings.
- **SCSI_MS_PC_CHANGEABLE** request for changeable settings.
- **SCSI_MS_PC_DEFAULT** request for default settings.
- **SCSI_MS_PC_SAVED** request for the saved values.

One of these following values must also be specified to determine the page code for the request:

- **SCSI_MS_PC_VENDOR** is the vendor specific page code.
- **SCSI_MS_PC_DISCO** is the disconnect/reconnect page code.
- **SCSI_MS_PC_CONTROL** is the control page code.
- **SCSI_MS_PC_LUN** is the protocol specific LUN page code.
- **SCSI_MS_PC_PORT** is the protocol specific port page code.
- **SCSI_MS_PC_POWER** is the power condition page code.
- **SCSI_MS_PC_INFORM** is the informational exceptions page code.
- **SCSI_MS_PC_ALL** will request all pages codes supported by the device.

The last value is optional and supports the following global flag:

- **SCSI_MS_DBD** disables returning block descriptors.

Example: Request for all current settings.

```
SCSIModeSense6(ui32InPipe,  ui32OutPipe,
               SCSI_MS_PC_CURRENT | SCSI_MS_PC_ALL,
               pui8Data,  pui32Size);
```

Returns:

This function returns the SCSI status from the command. The value will be either **SCSI_CMD_STATUS_PASS** or **SCSI_CMD_STATUS_FAIL**.

3.5.4.30 uint32_t USBHSCSIRead10 (uint32_t *ui32InPipe*, uint32_t *ui32OutPipe*, uint32_t *ui32LBA*, uint8_t * *pui8Data*, uint32_t * *pui32Size*, uint32_t *ui32NumBlocks*)

This function issues a SCSI Read(10) command to a device.

Parameters:

ui32InPipe is the USB IN pipe to use for this command.

ui32OutPipe is the USB OUT pipe to use for this command.

ui32LBA is the logical block address to read.

pui8Data is the data buffer to return the data.

pui32Size is the size of the buffer on entry and number of bytes read on exit.

ui32NumBlocks is the number of contiguous blocks to read from the device.

This function is used to issue a SCSI Read(10) command to a device. The *ui32LBA* parameter specifies the logical block address to read from the device. The data from this block will be returned in the buffer pointed to by *pui8Data*. The parameter *pui32Size* should indicate enough space to hold a full block size, or only the first *pui32Size* bytes of the LBA are returned.

Returns:

This function returns the results of the SCSI Read(10) command. The value will be either **SCSI_CMD_STATUS_PASS** or **SCSI_CMD_STATUS_FAIL**.

3.5.4.31 uint32_t USBHSCSIReadCapacities (uint32_t *ui32InPipe*, uint32_t *ui32OutPipe*, uint8_t * *pui8Data*, uint32_t * *pui32Size*)

This will issue the SCSI read capacities command to a device.

Parameters:

ui32InPipe is the USB IN pipe to use for this command.

ui32OutPipe is the USB OUT pipe to use for this command.

pui8Data is the data buffer to return the results into.

pui32Size is the size of buffer that was passed in on entry and the number of bytes returned.

This function should be used to issue a SCSI Read Capacities command to a mass storage device that is connected. To allow for multiple devices, the *ui32InPipe* and *ui32OutPipe* parameters indicate which USB pipes to use for this call.

Returns:

This function returns the SCSI status from the command. The value will be either **SCSI_CMD_STATUS_PASS** or **SCSI_CMD_STATUS_FAIL**.

3.5.4.32 uint32_t USBHSCSIReadCapacity (uint32_t *ui32InPipe*, uint32_t *ui32OutPipe*, uint8_t * *pui8Data*, uint32_t * *pui32Size*)

This will issue the SCSI read capacity command to a device.

Parameters:

ui32InPipe is the USB IN pipe to use for this command.

ui32OutPipe is the USB OUT pipe to use for this command.

pui8Data is the data buffer to return the results into.

pui32Size is the size of buffer that was passed in on entry and the number of bytes returned.

This function should be used to issue a SCSI Read Capacity command to a mass storage device that is connected. To allow for multiple devices, the *ui32InPipe* and *ui32OutPipe* parameters indicate which USB pipes to use for this call.

Note:

The *pui8Data* buffer pointer should have at least **SCSI_READ_CAPACITY_SZ** bytes of data or this function will overflow the buffer.

Returns:

This function returns the SCSI status from the command. The value will be either **SCSI_CMD_STATUS_PASS** or **SCSI_CMD_STATUS_FAIL**.

3.5.4.33 uint32_t USBHSCSIRequestSense (uint32_t *ui32InPipe*, uint32_t *ui32OutPipe*, uint8_t * *pui8Data*, uint32_t * *pui32Size*)

This function issues a SCSI Request Sense command to a device.

Parameters:

ui32InPipe is the USB IN pipe to use for this command.

ui32OutPipe is the USB OUT pipe to use for this command.

pui8Data is the data buffer to return the results into.

pui32Size is the size of the buffer on entry and number of bytes read on exit.

This function is used to issue a SCSI Request Sense command to a device. It will return the data in the buffer pointed to by *pui8Data*. The parameter *pui32Size* should have the allocation size in bytes of the buffer pointed to by *pui8Data*.

Returns:

This function returns the results of the SCSI Request Sense command. The value will be either **SCSI_CMD_STATUS_PASS** or **SCSI_CMD_STATUS_FAIL**.

3.5.4.34 uint32_t USBHSCSITestUnitReady (uint32_t *ui32InPipe*, uint32_t *ui32OutPipe*)

This function issues a SCSI Test Unit Ready command to a device.

Parameters:

ui32InPipe is the USB IN pipe to use for this command.

ui32OutPipe is the USB OUT pipe to use for this command.

This function is used to issue a SCSI Test Unit Ready command to a device. This call will simply return the results of issuing this command.

Returns:

This function returns the results of the SCSI Test Unit Ready command. The value will be either **SCSI_CMD_STATUS_PASS** or **SCSI_CMD_STATUS_FAIL**.

3.5.4.35 uint32_t USBHSCSIWrite10 (uint32_t *ui32InPipe*, uint32_t *ui32OutPipe*, uint32_t *ui32LBA*, uint8_t * *pui8Data*, uint32_t * *pui32Size*, uint32_t *ui32NumBlocks*)

This function issues a SCSI Write(10) command to a device.

This function is used to issue a SCSI Write(10) command to a device. The *ui32LBA* parameter specifies the logical block address on the device. The data to write to this block should be in the buffer pointed to by *pui8Data* parameter. The parameter *pui32Size* should indicate the amount of data to write to the specified LBA.

Parameters:

ui32InPipe is the USB IN pipe to use for this command.

ui32OutPipe is the USB OUT pipe to use for this command.

ui32LBA is the logical block address to read.

pui8Data is the data buffer to write out.

pui32Size is the size of the buffer.

ui32NumBlocks is the number of contiguous blocks to write to the device.

Returns:

This function returns the results of the SCSI Write(10) command. The value will be either **SCSI_CMD_STATUS_PASS** or **SCSI_CMD_STATUS_FAIL**.

3.5.5 Variable Documentation

3.5.5.1 const tUSBHostClassDriver g_sUSBHIDClassDriver

This constant global structure defines the HID Class Driver that is provided with the USB library.

3.5.5.2 const tUSBHostClassDriver g_sUSBHostAudioClassDriver

This constant global structure defines the Audio Class Driver that is provided with the USB library.

3.5.5.3 const tUSBHostClassDriver g_sUSBHostMSCClassDriver

This constant global structure defines the Mass Storage Class Driver that is provided with the USB library.

3.5.5.4 const tUSBHostClassDriver g_sUSBHubClassDriver

This constant global structure defines the Hub Class Driver that is provided with the USB library.

3.6 Host Device Interface

The USB library provides a set of example host device interfaces for a HID mouse, a HID keyboard and a mass storage device. The next few sections discusses each briefly and explain how their interfaces can be used by an application.

3.6.1 Mouse Device

The HID mouse device interface is controlled mainly through a callback function that is provided as part of the call to open the mouse device interface. In order to open an instance of the mouse device the application calls USBHMouseOpen() and passes in a callback function as well as some buffer data for use by the mouse device. The buffer provided is used internally by the mouse device and should not be used by the application. Once the device has been opened, the application should wait for a **USB_EVENT_CONNECTED** event to indicate that a mouse has been successfully detected and enumerated. At this point the application should call the USBHMouseInit() function to initialize the actual device that is connected. After this, the application can expect to start receiving the following events via the callback that was provided in the USBHMouseOpen() call:

- USBH_EVENT_HID_MS_PRESS
- USBH_EVENT_HID_MS_REL
- USBH_EVENT_HID_MS_X
- USBH_EVENT_HID_MS_Y

USBH_EVENT_HID_MS_PRESS
The ui32MsgParam parameter has one of the following values **HID_MOUSE_BUTTON_1**, **HID_MOUSE_BUTTON_2**, **HID_MOUSE_BUTTON_3** indicating which buttons have changed to the pressed state.
USBH_EVENT_HID_MS_REL
The ui32MsgParam parameter has one of the following values **HID_MOUSE_BUTTON_1**, **HID_MOUSE_BUTTON_2**, **HID_MOUSE_BUTTON_3** indicating which buttons have changed to the released state.
USBH_EVENT_HID_MS_X
The ui32MsgParam parameter has an 8 bit signed value indicating the delta in the X direction since the last update.
USBH_EVENT_HID_MS_Y
The ui32MsgParam parameter has an 8 bit signed value indicating the delta in the Y direction since the last update.
When the application is done using the mouse device it can call USBHMouseClose() to release the instance of the mouse device and free up the buffer that it passed to the mouse device.

3.6.2 Keyboard Device

Like the mouse, the HID keyboard device interface is controlled mainly through a callback function that is provided as part of the call to open the keyboard device interface. In order to open an instance of the keyboard device the application calls USBHKeyboardOpen() and passes in a callback function as well as some buffer data for use by the keyboard device. The buffer provided is used internally by the keyboard device and should not be used by the application. Once the device has been opened, the application should wait for a **USB_EVENT_CONNECTED** event to indicate that a keyboard has been successfully detected and enumerated. At this point the application should call the USBHKeyboardInit() function to initialize the actual keyboard device that is connected. After this, the application can expect to receive the following events via the callback that was provided in the USBHKeyboardOpen() call:

- USBH_EVENT_HID_KB_PRESS
- USBH_EVENT_HID_KB_REL
- USBH_EVENT_HID_KB_MOD

USBH_EVENT_HID_KB_PRESS
The ui32MsgParam parameter has the USB usage identifier for the key that has been pressed. It is up to the application to map this usage identifier to an actual printable character using the USBHKeyboardUsageToChar() function, or it can simple respond to the key press without echoing the key to any output device. It should be noted that "special" keys like the Caps Lock key require notifying the actual keyboard device that the host application has detected that the key has been pressed.
USBH_EVENT_HID_KB_REL
The ui32MsgParam parameter has the USB usage identifier for the key that has been released.
USBH_EVENT_HID_KB_MOD
The ui32MsgParam parameter has the current state of all of the modifier keys on the connected keyboard. This value is a bit mapped representation of the modifier keys that can have any of the following bits set:

- HID_KEYB_LEFT_CTRL
- HID_KEYB_LEFT_SHIFT
- HID_KEYB_LEFT_ALT

- HID_KEYB_LEFT_GUI
- HID_KEYB_RIGHT_CTRL
- HID_KEYB_RIGHT_SHIFT
- HID_KEYB_RIGHT_ALT
- HID_KEYB_RIGHT_GUI

3.7 Host Device Interface Definitions

Functions

- uint32_t USBHKeyboardClose (tUSBHKeyboard *psKbInstance)
- uint32_t USBHKeyboardInit (tUSBHKeyboard *psKbInstance)
- uint32_t USBHKeyboardModifierSet (tUSBHKeyboard *psKbInstance, uint32_t ui32Modifiers)
- tUSBHKeyboard * USBHKeyboardOpen (tUSBHIDKeyboardCallback pfnCallback, uint8_t *pui8Buffer, uint32_t ui32Size)
- uint32_t USBHKeyboardPollRateSet (tUSBHKeyboard *psKbInstance, uint32_t ui32PollRate)
- uint32_t USBHKeyboardUsageToChar (tUSBHKeyboard *psKbInstance, const tHIDKeyboardUsageTable *psTable, uint8_t ui8UsageID)
- uint32_t USBHMouseClose (tUSBHMouse *psMsInstance)
- uint32_t USBHMouseInit (tUSBHMouse *psMsInstance)
- tUSBHMouse * USBHMouseOpen (tUSBHIDMouseCallback pfnCallback, uint8_t *pui8Buffer, uint32_t ui32Size)

3.7.1 Detailed Description

The macros and functions defined in this section can be found in header files `host/usbhhidkeyboard.h` and `host/usbhhidmouse.h`.

3.7.2 Function Documentation

3.7.2.1 uint32_t USBHKeyboardClose (tUSBHKeyboard * *psKbInstance*)

This function is used close an instance of a keyboard.

Parameters:

psKbInstance is the instance value for this keyboard.

This function is used to close an instance of the keyboard that was opened with a call to USBHKeyboardOpen(). The *psKbInstance* value is the value that was returned when the application called USBHKeyboardOpen().

Returns:

This function returns 0 to indicate success any non-zero value indicates an error condition.

3.7.2.2 uint32_t USBHKeyboardInit (tUSBHKeyboard * *psKbInstance*)

This function is used to initialize a keyboard interface after a keyboard has been detected.

Parameters:

psKbInstance is the instance value for this keyboard.

This function should be called after receiving a **USB_EVENT_CONNECTED** event in the callback function provided by USBHKeyboardOpen(), however this function should only be called outside the callback function. This will initialize the keyboard interface and determine the keyboard's layout and how it reports keys to the USB host controller. The *psKbInstance* value is the value that was returned when the application called USBHKeyboardOpen(). This function only needs to be called once per connection event but it should be called every time a **USB_EVENT_CONNECTED** event occurs.

Returns:

This function returns 0 to indicate success any non-zero value indicates an error condition.

3.7.2.3 uint32_t USBHKeyboardModifierSet (tUSBHKeyboard * *psKbInstance*, uint32_t *ui32Modifiers*)

This function is used to set one of the fixed modifier keys on a keyboard.

Parameters:

psKbInstance is the instance value for this keyboard.

ui32Modifiers is a bit mask of the modifiers to set on the keyboard.

This function is used to set the modifier key states on a keyboard. The *ui32Modifiers* value is a bitmask of the following set of values:

- **HID_KEYB_NUM_LOCK**
- **HID_KEYB_CAPS_LOCK**
- **HID_KEYB_SCROLL_LOCK**
- **HID_KEYB_COMPOSE**
- **HID_KEYB_KANA**

Not all of these will be supported on all keyboards however setting values on a keyboard that does not have them should have no effect. The *psKbInstance* value is the value that was returned when the application called USBHKeyboardOpen(). If the value **HID_KEYB_CAPS_LOCK** is used it will modify the values returned from the USBHKeyboardUsageToChar() function.

Returns:

This function returns 0 to indicate success any non-zero value indicates an error condition.

3.7.2.4 tUSBHKeyboard * USBHKeyboardOpen (tUSBHIDKeyboardCallback *pfnCallback*, uint8_t * *pui8Buffer*, uint32_t *ui32Size*)

This function is used open an instance of a keyboard.

Parameters:

pfnCallback is the callback function to call when new events occur with the keyboard returned.

pui8Buffer is the memory used by the keyboard to interact with the USB keyboard.

ui32Size is the size of the buffer provided by *pui8Buffer*.

This function is used to open an instance of the keyboard. The value returned from this function should be used as the instance identifier for all other USBHKeyboard calls. The *pui8Buffer* memory buffer is used to access the keyboard. The buffer size required is at least enough to hold a normal report descriptor for the device. If there is not enough space only a partial report descriptor will be read out.

Returns:

Returns the instance identifier for the keyboard that is attached. If there is no keyboard present this will return 0.

3.7.2.5 uint32_t USBHKeyboardPollRateSet (tUSBHKeyboard * *psKbInstance*, uint32_t *ui32PollRate*)

This function is used to set the automatic poll rate of the keyboard.

Parameters:

psKbInstance is the instance value for this keyboard.

ui32PollRate is the rate in ms to cause the keyboard to update the host regardless of no change in key state.

This function will allow an application to tell the keyboard how often it should send updates to the USB host controller regardless of any changes in keyboard state. The *psKbInstance* value is the value that was returned when the application called USBHKeyboardOpen(). The *ui32PollRate* is the new value in ms for the update rate on the keyboard. This value is initially set to 0 which indicates that the keyboard should only to update when the keyboard state changes. Any value other than 0 can be used to force the keyboard to generate auto-repeat sequences for the application.

Returns:

This function returns 0 to indicate success any non-zero value indicates an error condition.

3.7.2.6 uint32_t USBHKeyboardUsageToChar (tUSBHKeyboard * *psKbInstance*, const tHIDKeyboardUsageTable * *psTable*, uint8_t *ui8UsageID*)

This function is used to map a USB usage ID to a printable character.

Parameters:

psKbInstance is the instance value for this keyboard.

psTable is the table to use to map the usage ID to characters.

ui8UsageID is the USB usage ID to map to a character.

This function is used to map a USB usage ID to a character. The provided *psTable* is used to perform the mapping and is described by the tHIDKeyboardUsageTable type defined structure. See the documentation on the tHIDKeyboardUsageTable structure for more details on the internals of this structure. This function uses the current state of the shift keys and the Caps Lock key to modify the data returned by this function. The psTable structure has values indicating which keys are modified by Caps and alternate values for shifted cases. The number of bytes returned from Lock this function depends on the *psTable* structure passed in as it holds the number of bytes per character in the table.

Returns:

Returns the character value for the given usage id.

3.7.2.7 uint32_t USBHMouseClose (tUSBHMouse * *psMsInstance*)

This function is used close an instance of a mouse.

Parameters:

psMsInstance is the instance value for this mouse.

This function is used to close an instance of the mouse that was opened with a call to USBHMouseOpen(). The *psMsInstance* value is the value that was returned when the application called USBHMouseOpen().

Returns:
Returns 0.

3.7.2.8 uint32_t USBHMouseInit (tUSBHMouse * *psMsInstance*)

This function is used to initialize a mouse interface after a mouse has been detected.
Parameters:
psMsInstance is the instance value for this mouse.
This function should be called after receiving a **USB_EVENT_CONNECTED** event in the callback function provided by USBHMouseOpen(), however it should only be called outside of the callback function. This will initialize the mouse interface and determine how it reports events to the USB host controller. The *psMsInstance* value is the value that was returned when the application called USBHMouseOpen(). This function only needs to be called once per connection event but it should be called every time a **USB_EVENT_CONNECTED** event occurs.
Returns:
Non-zero values should be assumed to indicate an error condition.

3.7.2.9 tUSBHMouse * USBHMouseOpen (tUSBHIDMouseCallback *pfnCallback*, uint8_t * *pui8Buffer*, uint32_t *ui32Size*)

This function is used open an instance of a mouse.
Parameters:
pfnCallback is the callback function to call when new events occur with the mouse returned.
pui8Buffer is the memory used by the driver to interact with the USB mouse.
ui32Size is the size of the buffer provided by *pui8Buffer*.
This function is used to open an instance of the mouse. The value returned from this function should be used as the instance identifier for all other USBHMouse calls. The *pui8Buffer* memory buffer is used to access the mouse. The buffer size required is at least enough to hold a normal report descriptor for the device.
Returns:
Returns the instance identifier for the mouse that is attached. If there is no mouse present this will return 0.

3.8 Host Programming Examples

The USB library provides examples for three host applications that can access mass storage devices and HID keyboard and mouse devices. These next sections cover the basics of each of these three applications and how they interact with the USB library.

3.8.1 Application Initialization

The USB library host stack initialization is handled in the USBHCDInit() function. This function should be called after registering class drivers using USBHCDRegisterDrivers() and, optionally, configuring power pins using USBHCDPowerConfigInit(). Both of these functions are described later.
The USBHCDInit() function takes three parameters, the first of which specifies which USB controller to initialize. This value is a zero based index of the host controller to initialize.

The next two parameters specify a memory pool for use by the host controller driver. The size of this buffer should be at least large enough to hold a typical configuration descriptor for devices that are going to be supported. This value is system dependent so it is left to the application to set the size, however it should never be less than 32 bytes and in most cases should be at least 64 bytes. If there is not enough memory to load a configuration descriptor from a device, the device is not recognized by USB library's host controller driver.
The USB library also provides a method to shut down an instance of the host controller driver by calling the USBHCDTerm() function. The USBHCDTerm() function should be called any time the application wants to shut down the USB host controller in order to disable it, or possibly switch modes in the case of a dual role controller.
The USB library assumes that the power pin configuration has an active high signal for controlling the external power. If this is not the case or if the application wants control over the power fault logic provided by the library, then the application should call the USBHCDPowerConfigInit() function before calling USBHCDInit() in order to properly configure the power control pins. The polarity of the power pin, the polarity of the the power fault pin and any actions taken in response to a power fault are all controlled by passing a combination of sets of values in the *ulPwrConfig* parameter. See the documentation for the USBHCDPowerConfigInit() function for more details on this function.

3.8.2 Application Interface

The USB library host stack requires some portion of the code to not run in the interrupt handler so it provides the USBHCDMain() function that must be called periodically in the main application. This can be as a result of a timer tick or just once per main loop in a simple application. It should not be called in an interrupt handler. Calling the function too often is harmless as it simply returns if the USB host stack has nothing to do. Calling USBHCDMain() too infrequently can cause enumeration to take longer than normal. It is up to the application to prioritize the importance of USB communications by calling USBHCDMain() at a rate that is reasonable to the application.
All support devices must have a host class driver loaded in order to communicate with each type of device that is supported. The details of interacting with these host class drivers is explained in the host class driver sections that follow in this document.

3.8.3 Application Termination

When the application needs to shut down the host controller it needs to shutdown all host class drivers and then shut down the host controller itself. This gives the host class drivers a chance to close cleanly by calling each host class driver's close function. Then the USBHCDTerm() function should be called to shut down the host controller. This sequence leaves the USB controller and the USB library stack in a state so that it is ready to be re-initialized or in order to switch USB mode from host to device.

3.8.4 Example Application Setup

The following example shows the basic setup code needed for any application that is using the USB library in host mode. The g_pui8HCDPool array which is passed in to the USBHCDInit() is used as heap memory for by the USB library and thus the memory should not be used by the application. In this example, the g_ppsHostClassDrivers array holds both HID and MSC class drivers making it possible for both types of devices to be supported. However if the application only needs to include the classes that it needs to support in order to save code and memory space. The pin and peripheral configuration is left to the

application as the USB pins may not always be on the same physical pins for every part supported by the USB library. The macros provided in the pin_map.h file included with DriverLib can be used to indicate which pin and peripheral to use for a given part. See the DriverLib documentation on pin mapping for more details on how it provides mapping of peripherals to pins on devices. The USBHCDRegisterDrivers() call passes in the static array of supported USB host class drivers that are supported by the application. As shown in the example, the application should always call the USB device interfaces open routines before calling USBHCDInit() since this call enables the USB host controller and start enumerating any connected device. If the device interface has not been called it may miss the connection notification and could miss some state information that occurred before the device interface was ready.

Example: Basic Configuration as Host

```
//*****************************************************************************
//
// The size of the host controller's memory pool in bytes.
//
//*****************************************************************************
#define HCD_MEMORY_SIZE         128

//*****************************************************************************
//
// The memory pool to provide to the Host controller driver.
//
//*****************************************************************************
uint8_t g_pui8HCDPool[HCD_MEMORY_SIZE];

//*****************************************************************************
//
// The global that holds all of the host drivers in use in the application.
// In this case, only the Keyboard class is loaded.
//
//*****************************************************************************
static tUSBHostClassDriver const * const g_ppsHostClassDrivers[] =
{
    &g_sUSBHIDClassDriver,
    &g_sUSBHostMSCClassDriver
};

//*****************************************************************************
//
// This global holds the number of class drivers in the g_ppsHostClassDrivers
// list.
//
//*****************************************************************************
static const uint32_t g_ui32NumHostClassDrivers =
    sizeof(g_ppsHostClassDrivers) / sizeof(tUSBHostClassDriver *);

    ...

    //
    // Enable Clocking to the USB controller.
    //
    SysCtlPeripheralEnable(SYSCTL_PERIPH_USB0);

    //
    // Enable the peripherals used by this example.
    //
    SysCtlPeripheralEnable(SYSCTL_PERIPH_UART0);
    SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOH);

    //
    // Set the USB0EPEN and USB0PFLT pins to be controlled by the USB
    // controller.
```

```
//
GPIOPinTypeUSBDigital(GPIO_PORTH_BASE, GPIO_PIN_3 | GPIO_PIN_4);

//
// Register the host class drivers.
//
USBHCDRegisterDrivers(0, g_ppsUSBHostClassDrivers,
                      g_ui32NumHostClassDrivers);

...

//
// Call any open routines on the device class interfaces here so that they
// are ready to receive callbacks if the device is already inserted on
// power on.
//
// Eg: USBHMSCDriveOpen(0, MSCCallback);
//

...

//
// Initialize the host controller.
//
USBHCDInit(0, g_pui8HCDPool, HCD_MEMORY_SIZE);
```

3.8.5 Host HID Mouse Programming Example

The USB library HID mouse example provides support for HID mouse devices that support the USB HID mouse BIOS protocol. Since most mice support the BIOS protocol nearly any mouse should be able to be connected and be supported. The initial call to USBHMouseOpen() prepares the mouse device application interface to receive notifications from any USB mouse device that is connected. Since the mouse interface needs some basic configuration after being connected the application needs to wait for the mouse to be connected and then call the USBHMouseInit() function to finish off the mouse configuration.

Example: Mouse Configuration

```
//
// Open an instance of the mouse driver.  The mouse does not need
// to be present at this time, this just saves a place for it and allows
// the applications to be notified when a mouse is present.
//
g_psMouseInstance = USBHMouseOpen(MouseCallback,
                                  g_pui8Buffer,
                                  128);

...

//
// Main loop of application.
//
while(1)
{
    switch(iMouseState)
    {
        //
        // This state is entered when they mouse is first detected.
        //
        case MOUSE_INIT:
        {
            //
            // Initialized the newly connected mouse.
```

```
                //
                USBHMouseInit(g_psMouseInstance);

                //
                // Proceed to the mouse connected state.
                //
                iMouseState = MOUSE_CONNECTED;

                break;
            }
            case MOUSE_CONNECTED:
            {
                break;
            }
            case MOUSE_NOT_CONNECTED:
            default:
            {
                break;
            }
        }

        //
        // Periodic call the main loop for the Host controller driver.
        //
        USBHCDMain();
    }
    ...
```

Once the mouse has been configured the application's mouse callback routine is notified any time there is a state change with the mouse. This includes the switching to the MOUSE_INIT state when a **USB_EVENT_CONNECTED** event occurs in order to trigger initialization of the mouse device. The **USB_EVENT_DISCONNECTED** simply switches the state of the application to let it know that the mouse is no longer present. The remaining events are mouse state changes that can be used by the application to move a cursor or make a selection based on a mouse click.

Example: Mouse Callback Routine

```
uint32_t
MouseCallback(tUSBHMouse *psMsInstance, uint32_t ui32Event,
              uint32_t ui32MsgParam, void *pvMsgData)
{
    switch(ui32Event)
    {
        //
        // New mouse detected.
        //
        case USB_EVENT_CONNECTED:
        {
            iMouseState = MOUSE_INIT;
            break;
        }

        //
        // Mouse has been unplugged.
        //
        case USB_EVENT_DISCONNECTED:
        {
            iMouseState = MOUSE_NOT_CONNECTED;
            break;
        }

        //
        // New Mouse events detected.
        //
        case USBH_EVENT_HID_MS_PRESS:
        {
```

```
            break;
        }
        case USBH_EVENT_HID_MS_REL:
        {
            break;
        }
        case USBH_EVENT_HID_MS_X:
        {
            break;
        }
        case USBH_EVENT_HID_MS_Y:
        {
            break;
        }
    }
    return(0);
}
```

3.8.6 Host HID Keyboard Programming Example

The USB library HID keyboard example provides support for HID keyboard devices that support the USB HID keyboard BIOS protocol. Since most keyboards support the BIOS protocol most keyboards should be able to be connected and be supported. The initial call to USBHKeyboardOpen() prepares the keyboard device application interface to receive notifications from any USB keyboard device that is connected. The keyboard interface needs some basic configuration and needs to set the current state of LEDs on the keyboard, the application must wait for the keyboard to be connected and then call the USBHKeyboardInit() function.

Example: Keyboard Configuration

```
    ...

    //
    // Open an instance of the keyboard driver.  The keyboard does not need
    // to be present at this time, this just save a place for it and allows
    // the applications to be notified when a keyboard is present.
    //
    g_psKeyboardInstance = USBHKeyboardOpen(KeyboardCallback,
                                            g_pui8Buffer,
                                            128);

    //
    // The main loop for the application.
    //
    while(1)
    {
        switch(iKeyboardState)
        {
            //
            // This state is entered when they keyboard is first detected.
            //
            case KEYBOARD_INIT:
            {
                //
                // Initialized the newly connected keyboard.
                //
                USBHKeyboardInit(g_psKeyboardInstance);

                //
                // Proceed to the keyboard connected state.
                //
                iKeyboardState = KEYBOARD_CONNECTED;
```

```
                break;
            }
            case KEYBOARD_UPDATE:
            {
                //
                // If the application detected a change that required an
                // update to be sent to the keyboard to change the modifier
                // state then call it and return to the connected state.
                //
                iKeyboardState = KEYBOARD_CONNECTED;

                USBHKeyboardModifierSet(g_psKeyboardInstance,
                                        g_ui32Modifiers);
            }
            case KEYBOARD_CONNECTED:
            {
                break;
            }
            case KEYBOARD_NOT_CONNECTED:
            default:
            {
                break;
            }
        }

        //
        // Periodic call the main loop for the Host controller driver.
        //
        USBHCDMain();
    }
```

Much like the mouse, the keyboard handles the reception of events entirely in the callback handler. This function should receive and store the keyboard events and handle them in the main program loop when the device is in the connected state. The **USB_EVENT_CONNECTED** lets the main loop know that it is time to call the USBHKeyboardInit() routine to configure the keyboard. The **USB_EVENT_DISCONNECTED** event simply informs the application that the keyboard is not longer present and not to expect any more callbacks until another **USB_EVENT_CONNECTED** occurs. The remaining events all indicate that a key has been pressed or released. Normal key presses/releases generate **USBH_EVENT_HID_KB_PRESS** or **USBH_EVENT_HID_KB_REL** events while hitting keys like the shift, ctrl, alt and gui keys generate **USBH_EVENT_HID_KB_MOD** events.

Example: Keyboard Callback

```
uint32_t
KeyboardCallback(tUSBHKeyboard *psKbInstance, uint32_t ui32Event,
                 uint32_t ui32MsgParam, void *pvMsgData)
{
    uint8_t ui8Char;

    switch(ui32Event)
    {
        //
        // New keyboard detected.
        //
        case USB_EVENT_CONNECTED:
        {
            iKeyboardState = KEYBOARD_INIT;
            break;
        }

        //
        // Keyboard has been unplugged.
        //
        case USB_EVENT_DISCONNECTED:
```

```
            {
                iKeyboardState = KEYBOARD_NOT_CONNECTED;
                break;
            }

            //
            // New Key press detected.
            //
            case USBH_EVENT_HID_KB_PRESS:
            {
                //
                // ui32MsgParam holds the USB Usage ID.
                //
                break;
            }
            case USBH_EVENT_HID_KB_MOD:
            {
                //
                // ui32MsgParam holds the USB Modifier bit mask.
                //
                break;
            }
            case USBH_EVENT_HID_KB_REL:
            {
                //
                // ui32MsgParam holds the USB Usage ID.
                //
                break;
            }
        }
        return(0);
}
```

3.8.7 Host Mass Storage Programming Example

The following programming example demonstrates some of the basic interfaces that are available from the USB mass storage class application interface. See the "Basic Configuration as Host" example above for the initial configuration. The application should call USBHMSCDriveOpen() in order for the application to be ready for a new mass storage device. The application should also wait for the mass storage device to be ready to receive commands by calling USBHMSCDriveReady() and waiting for the value returned to go to 0 before attempting to read or write the device. Typically the reading and writing of the device is left to a file system layer as is the case in the example application, however the calls to directly read or write a block are shown in the example below.

Example: Mass Storage Coding Example

```
    //
    // Open an instance of the mass storage class driver.
    //
    g_psMSCInstance = USBHMSCDriveOpen(0, MSCCallback);

    ...

    //
    // Wait for the drive to become ready.
    //
    while(USBHMSCDriveReady(g_psMSCInstance))
    {
        //
        // System level delay call should be here to give the device time to
        // become ready.
        //
        SysCtlDelay(g_ui32ClockRate / 100);
```

```
}

...

//
// Block Read example.
//
USBHMSCBlockRead(g_psMSCInstance, ui32LBA, pui8Data, 1);

...

//
// Block Write example.
//
USBHMSCBlockWrite(g_psMSCInstance, ui32LBA, pui8Data, 1);

...
```

4 General Purpose Functions

4.1 Introduction

This chapter describes the set of USB library data types and functions which are of general use in the development of USB applications using this library These elements are not specific to USB host or device operation.
The functions and types described here fall into three main categories:

- Definitions of USB standard types (as found in Chapter 9 of the USB 2.0 specification) and functions to parse them.
- Functions relating to host/device mode switching for On-The-Go or dual mode applications.
- USB device class header files.

Source Code Overview

Source code and headers for the general-purpose USB functions can be found in the top level directory of the USB library tree, typically `libraries/communications/usb/f2838x/include` and `libraries/communications/usb/f2838x/source`.

`usblib.h` The main header file for the USB library containing all data types and definitions which are common across the library as a whole. Prototypes for general-purpose API functions are also included. All clients of the USB Library should include this header.

`usb_ids.h` The header file containing labels defining the Texas Instruments USB vendor ID (VID) and product IDs (PIDs) for each of the example devices provided in USB-capable evaluation kits.

`usbmsc.h` The header file containing definitions specific to the USB Mass Storage Class.

`usbcdc.h` The header file containing definitions specific to the USB Communication Device Class.

`usbhid.h` The header file containing definitions specific to the USB Human Interface Device Class.

`usbdesc.c` The source code for a set of functions allowing parsing of USB descriptors.

`usbbuffer.c` The source code for a set of functions use to support buffering of USB endpoint data streams in some applications.

usbringbuf.c	The source code for a set of functions implementing simple ring buffers.
usbmode.c	The source code for a set of functions related to switching between host and device modes of operation.
usbtick.c	The source code for internal USB library tick handler functions. This file does not include any functions accessible by applications.
usblibpriv.h	The private header file used to share variables and definitions between the various components of the USB Library. Client applications must not include this header.

4.2 Function Definitions

Defines

- USB_DESC_ANY
- USBERR_DEV_RX_DATA_ERROR
- USBERR_DEV_RX_FIFO_FULL
- USBERR_DEV_RX_OVERRUN
- USBERR_HOST_EP0_ERROR
- USBERR_HOST_EP0_NAK_TO
- USBERR_HOST_IN_DATA_ERROR
- USBERR_HOST_IN_ERROR
- USBERR_HOST_IN_FIFO_FULL
- USBERR_HOST_IN_NAK_TO
- USBERR_HOST_IN_NOT_COMP
- USBERR_HOST_IN_PID_ERROR
- USBERR_HOST_IN_STALL
- USBERR_HOST_OUT_ERROR
- USBERR_HOST_OUT_NAK_TO
- USBERR_HOST_OUT_NOT_COMP
- USBERR_HOST_OUT_STALL

Enumerations

- tUSBMode

Functions

- tDescriptorHeader * USBDescGet (tDescriptorHeader *psDesc, uint32_t ui32Size, uint32_t ui32Type, uint32_t ui32Index)
- tInterfaceDescriptor * USBDescGetInterface (tConfigDescriptor *psConfig, uint32_t ui32Index, uint32_t ui32Alt)
- tEndpointDescriptor * USBDescGetInterfaceEndpoint (tInterfaceDescriptor *psInterface, uint32_t ui32Index, uint32_t ui32Size)
- uint32_t USBDescGetNum (tDescriptorHeader *psDesc, uint32_t ui32Size, uint32_t ui32Type)
- uint32_t USBDescGetNumAlternateInterfaces (tConfigDescriptor *psConfig, uint8_t ui8InterfaceNumber)

- void USBStackModeSet (uint32_t ui32Index, tUSBMode iUSBMode, tUSBModeCallback pfnCallback)

4.2.1 Detailed Description

This group of functions relates to standard USB descriptor parsing and host/device mode control. Source for these functions can be found in files `usbenum.c` and `usbmode.c`. Header file `usblib.h` contains prototypes for these functions along with all data type definitions which are not device or host specific.

4.2.2 Define Documentation

4.2.2.1 USB_DESC_ANY

Definition:

```
#define USB_DESC_ANY
```

Description:

The USB_DESC_ANY label is used as a wild card in several of the descriptor parsing APIs to determine whether or not particular search criteria should be ignored.

4.2.2.2 USBERR_DEV_RX_DATA_ERROR

Definition:

```
#define USBERR_DEV_RX_DATA_ERROR
```

Description:

The device detected a CRC error in received data.

4.2.2.3 USBERR_DEV_RX_FIFO_FULL

Definition:

```
#define USBERR_DEV_RX_FIFO_FULL
```

Description:

The device receive FIFO is full.

4.2.2.4 USBERR_DEV_RX_OVERRUN

Definition:

```
#define USBERR_DEV_RX_OVERRUN
```

Description:

The device was unable to receive a packet from the host since the receive FIFO is full.

4.2.2.5 USBERR_HOST_EP0_ERROR

Definition:

```
#define USBERR_HOST_EP0_ERROR
```

Description:

The host failed to communicate with a device via an endpoint zero.

4.2.2.6 USBERR_HOST_EP0_NAK_TO

Definition:

```
#define USBERR_HOST_EP0_NAK_TO
```

Description:

The host received NAK on endpoint 0 for longer than the configured timeout.

4.2.2.7 USBERR_HOST_IN_DATA_ERROR

Definition:

```
#define USBERR_HOST_IN_DATA_ERROR
```

Description:

The host detected a CRC or bit-stuffing error (isochronous mode).

4.2.2.8 USBERR_HOST_IN_ERROR

Definition:

```
#define USBERR_HOST_IN_ERROR
```

Description:

The host failed to communicate with a device via an IN endpoint.

4.2.2.9 USBERR_HOST_IN_FIFO_FULL

Definition:

```
#define USBERR_HOST_IN_FIFO_FULL
```

Description:

The host receive FIFO is full.

4.2.2.10 USBERR_HOST_IN_NAK_TO

Definition:

```
#define USBERR_HOST_IN_NAK_TO
```

Description:

The host received NAK on an IN endpoint for longer than the specified timeout period (interrupt, bulk and control modes).

4.2.2.11 USBERR_HOST_IN_NOT_COMP

Definition:

```
#define USBERR_HOST_IN_NOT_COMP
```

Description:

The host did not receive a response from a device.

4.2.2.12 USBERR_HOST_IN_PID_ERROR

Definition:

```
#define USBERR_HOST_IN_PID_ERROR
```

Description:

The host received an invalid PID in a transaction.

4.2.2.13 USBERR_HOST_IN_STALL

Definition:

```
#define USBERR_HOST_IN_STALL
```

Description:

The host received a stall on an IN endpoint.

4.2.2.14 USBERR_HOST_OUT_ERROR

Definition:

```
#define USBERR_HOST_OUT_ERROR
```

Description:

The host failed to communicate with a device via an OUT endpoint.

4.2.2.15 USBERR_HOST_OUT_NAK_TO

Definition:

```
#define USBERR_HOST_OUT_NAK_TO
```

Description:

The host received NAK on an OUT endpoint for longer than the specified timeout period (bulk, interrupt and control modes).

4.2.2.16 USBERR_HOST_OUT_NOT_COMP

Definition:

```
#define USBERR_HOST_OUT_NOT_COMP
```

Description:

The host did not receive a response from a device (isochronous mode).

4.2.2.17 USBERR_HOST_OUT_STALL

Definition:

```
#define USBERR_HOST_OUT_STALL
```

Description:

The host received a stall on an OUT endpoint.

4.2.3 Typedef Documentation

4.2.3.1 tUSBCallback

USB callback function.

Definition:

```
#define uint32_t(
                  *
                  )

*0em                  group__general__usblib__api_g5cac75897ad5d3e7408a06
                  tUSBCallback
                  (void
                  *
                  pvCBData,
```

```
                                uint32_t
                                ui32Event,
                                uint32_t
                                ui32MsgParam,
                                void
                                *
                                pvMsgData)
```

Parameters:

pvCBData is the callback pointer associated with the instance generating the callback. This is a value provided by the client during initialization of the instance making the callback.

ui32Event is the identifier of the asynchronous event which is being notified to the client.

ui32MsgParam is an event-specific parameter.

pvMsgData is an event-specific data pointer.

Description:

A function pointer provided to the USB layer by the application which will be called to notify it of all asynchronous events relating to data transmission or reception. This callback is used by device class drivers and host pipe functions.

Returns:

Returns an event-dependent value.

4.2.4 Enumeration Documentation

4.2.4.1 tUSBMode

Description:

The operating mode required by the USB library client. This type is used by applications which wish to be able to switch between host and device modes by calling the USBStackModeSet() API.

Enumerators:

eUSBModeDevice Operate in USB device mode with active monitoring of VBUS and the ID pin must be pulled to a logic high value.

eUSBModeHost Operate in USB host mode with active monitoring of VBUS and the ID pin must be pulled to a logic low value.

eUSBModeOTG Operate as an On-The-Go device which requires both VBUS and ID to be connected directly to the USB controller from the USB connector.

eUSBModeNone A marker indicating that no USB mode has yet been set by the application.

eUSBModeForceHost Force host mode so that the VBUS and ID pins are not used or monitored by the USB controller.

eUSBModeForceDevice Forcing device mode so that the VBUS and ID pins are not used or monitored by the USB controller.

4.2.5 Function Documentation

4.2.5.1 USBDescGet

Determines the number of individual descriptors of a particular type within a supplied buffer.

Prototype:

```
tDescriptorHeader *
USBDescGet(tDescriptorHeader *psDesc,
           uint32_t ui32Size,
           uint32_t ui32Type,
           uint32_t ui32Index)
```

Parameters:

psDesc points to the first byte of a block of standard USB descriptors.

ui32Size is the number of bytes of descriptor data found at pointer *psDesc*.

ui32Type identifies the type of descriptor that is to be found. If the value is **USB_DESC_ANY**, the function returns a pointer to the n-th descriptor regardless of type.

ui32Index is the zero based index of the descriptor whose pointer is to be returned. For example, passing value 1 in *ui32Index* returns the second matching descriptor.

Description:

Return a pointer to the n-th descriptor of a particular type found in the block of *ui32Size* bytes starting at *psDesc*.

Returns:

Returns a pointer to the header of the required descriptor if found or NULL otherwise.

4.2.5.2 USBDescGetInterface

Returns a pointer to the n-th interface descriptor in a configuration descriptor that applies to the supplied alternate setting number.

Prototype:

```
tInterfaceDescriptor *
USBDescGetInterface(tConfigDescriptor *psConfig,
                    uint32_t ui32Index,
                    uint32_t ui32Alt)
```

Parameters:

psConfig points to the first byte of a standard USB configuration descriptor.

ui32Index is the zero based index of the interface that is to be found. If *ui32Alt* is set to a value other than **USB_DESC_ANY**, this will be equivalent to the interface number being searched for.

ui32Alt is the alternate setting number which is to be searched for. If this value is **USB_DESC_ANY**, the alternate setting is ignored and all interface descriptors are considered in the search.

Description:

Return a pointer to the n-th interface descriptor found in the supplied configuration descriptor. If *ui32Alt* is not **USB_DESC_ANY**, only interface descriptors which are part of the supplied alternate setting are considered in the search otherwise all interface descriptors are considered.

Note that, although alternate settings can be applied on an interface-by- interface basis, the number of interfaces offered is fixed for a given config descriptor. Hence, this function will correctly find the unique interface descriptor for that interface's alternate setting number *ui32Alt* if *ui32Index* is set to the required interface number and *ui32Alt* is set to a valid alternate setting number for that interface.

Returns:

Returns a pointer to the required interface descriptor if found or NULL otherwise.

4.2.5.3 USBDescGetInterfaceEndpoint

Return a pointer to the n-th endpoint descriptor in the supplied interface descriptor.

Prototype:

```
tEndpointDescriptor *
USBDescGetInterfaceEndpoint(tInterfaceDescriptor *psInterface,
                            uint32_t ui32Index,
                            uint32_t ui32Size)
```

Parameters:

psInterface points to the first byte of a standard USB interface descriptor.

ui32Index is the zero based index of the endpoint that is to be found.

ui32Size contains the maximum number of bytes that the function may search beyond *psInterface* while looking for the requested endpoint descriptor.

Description:

Return a pointer to the n-th endpoint descriptor found in the supplied interface descriptor. If the *ui32Index* parameter is invalid (greater than or equal to the bNumEndpoints field of the interface descriptor) or the endpoint cannot be found within *ui32Size* bytes of the interface descriptor pointer, the function will return NULL.

Note that, although the USB 2.0 specification states that endpoint descriptors must follow the interface descriptor that they relate to, it also states that device specific descriptors should follow any standard descriptor that they relate to. As a result, we cannot assume that each interface descriptor will be followed by nothing but an ordered list of its own endpoints and, hence, the function needs to be provided *ui32Size* to limit the search range.

Returns:

Returns a pointer to the requested endpoint descriptor if found or NULL otherwise.

4.2.5.4 USBDescGetNum

Determines the number of individual descriptors of a particular type within a supplied buffer.

Prototype:

```
uint32_t
USBDescGetNum(tDescriptorHeader *psDesc,
              uint32_t ui32Size,
              uint32_t ui32Type)
```

Parameters:

psDesc points to the first byte of a block of standard USB descriptors.

ui32Size is the number of bytes of descriptor data found at pointer *psDesc*.

ui32Type identifies the type of descriptor that is to be counted. If the value is **USB_DESC_ANY**, the function returns the total number of descriptors regardless of type.

Description:

This function can be used to count the number of descriptors of a particular type within a block of descriptors. The caller can provide a specific type value which the function matches against the second byte of each descriptor or, alternatively, can specify **USB_DESC_ANY** to have the function count all descriptors regardless of their type.

Returns:

Returns the number of descriptors found in the supplied block of data.

4.2.5.5 USBDescGetNumAlternateInterfaces

Determines the number of different alternate configurations for a given interface within a configuration descriptor.

Prototype:

```
uint32_t
USBDescGetNumAlternateInterfaces(tConfigDescriptor *psConfig,
                                 uint8_t ui8InterfaceNumber)
```

Parameters:

psConfig points to the first byte of a standard USB configuration descriptor.

ui8InterfaceNumber is the interface number for which the number of alternate configurations is to be counted.

Description:

This function can be used to count the number of alternate settings for a specific interface within a configuration.

Returns:

Returns the number of alternate versions of the specified interface or 0 if the interface number supplied cannot be found in the config descriptor.

4.2.5.6 USBStackModeSet

Allows dual mode application to switch between USB device and host modes and provides a method to force the controller into the desired mode.

Prototype:

```
void
USBStackModeSet(uint32_t ui32Index,
                tUSBMode iUSBMode,
                tUSBModeCallback pfnCallback)
```

Parameters:

ui32Index specifies the USB controller whose mode of operation is to be set. This parameter must be set to 0.

iUSBMode indicates the mode that the application wishes to operate in. Valid values are **eUSBModeDevice** to operate as a USB device and **eUSBModeHost** to operate as a USB host.

pfnCallback is a pointer to a function which the USB library will call each time the mode is changed to indicate the new operating mode. In cases where *iUSBMode* is set to either **eUSBModeDevice** or **eUSBModeHost**, the callback will be made immediately to allow the application to perform any host or device specific initialization.

Description:

This function allows a USB application that can operate in host or device mode to indicate to the USB stack the mode that it wishes to use. The caller is responsible for cleaning up the interface and removing itself from the bus prior to making this call and reconfiguring afterwards. The *pfnCallback* function can be a NULL(0) value to indicate that no notification is required.

For successful dual mode mode operation, an application must register USB0DualModeIntHandler() as the interrupt handler for the USB0 interrupt. This handler is responsible for steering interrupts to the device or host stack depending upon the chosen mode. Devices which do not require dual mode capability should register either *USB0DeviceIntHandler()* or *USB0HostIntHandler()* instead. Registering *USB0DualModeIntHandler()* for a single mode application will result in an application

binary larger than required since library functions for both USB operating modes will be included even though only one mode is required.

Single mode applications (those offering exclusively USB device or USB host functionality) are only required to call this function if they need to force the mode of the controller to Host or Device mode. This is usually in the event that the application needs to reused the USBVBUS and/or USBID pins as GPIOs.

Returns:

None.

4.3 USB Events

Data Structures

- struct tEventInfo

Defines

- #define USB_EVENT_COMP_CONFIG
- #define USB_EVENT_COMP_EP_CHANGE
- #define USB_EVENT_COMP_IFACE_CHANGE
- #define USB_EVENT_COMP_STR_CHANGE
- #define USB_EVENT_CONNECTED
- #define USB_EVENT_DATA_REMAINING
- #define USB_EVENT_DISCONNECTED
- #define USB_EVENT_ERROR
- #define USB_EVENT_POWER_DISABLE
- #define USB_EVENT_POWER_ENABLE
- #define USB_EVENT_POWER_FAULT
- #define USB_EVENT_REQUEST_BUFFER
- #define USB_EVENT_RESUME
- #define USB_EVENT_RX_AVAILABLE
- #define USB_EVENT_SCHEDULER
- #define USB_EVENT_SOF
- #define USB_EVENT_STALL
- #define USB_EVENT_SUSPEND
- #define USB_EVENT_TX_COMPLETE
- #define USB_EVENT_UNKNOWN_CONNECTED

4.3.1 Detailed Description

defined events.

4.3.2 Define Documentation

4.3.2.1 #define USB_EVENT_COMP_CONFIG

This define is used with a device class's pfnDeviceHandler handler function to indicate that the USB library has changed the configuration descriptor. This allows the class to make

final adjustments to the configuration descriptor. This event is typically due to the class being included in a composite device.
The *pvInstance* is a pointer to an instance of the device being accessed.
The *ui32Request* is USB_EVENT_COMP_CONFIG.
The *pvRequestData* is a pointer to the beginning of the configuration descriptor for the device instance.

4.3.2.2 #define USB_EVENT_COMP_EP_CHANGE

This define is used with a device class's pfnDeviceHandler handler function to indicate that the USB library has changed the endpoint number. This event is typically due to the class being included in a composite device.
The *pvInstance* is a pointer to an instance of the device being accessed.
The *ui32Request* is USB_EVENT_COMP_EP_CHANGE.
The *pvRequestData* is a pointer to a two byte array where the first value is the old endpoint number and the second is the new endpoint number. The endpoint numbers should be exactly as USB specification defines them and bit 7 set indicates an IN endpoint and bit 7 clear indicates an OUT endpoint.

4.3.2.3 #define USB_EVENT_COMP_IFACE_CHANGE

This define is used with a device class's pfnDeviceHandler handler function to indicate that the USB library has changed the interface number. This event is typically due to the class being included in a composite device.
The *pvInstance* is a pointer to an instance of the device being accessed.
The *ui32Request* is USB_EVENT_COMP_IFACE_CHANGE.
The *pvRequestData* is a pointer to a two byte array where the first value is the old interface number and the second is the new interface number.

4.3.2.4 #define USB_EVENT_COMP_STR_CHANGE

This define is used with a device class's pfnDeviceHandler handler function to indicate that the USB library has changed the string index number for a string. This event is typically due to the class being included in a composite device.
The *pvInstance* is a pointer to an instance of the device being accessed.
The *ui32Request* is USB_EVENT_COMP_STR_CHANGE.
The *pvRequestData* is a pointer to a two byte array where the first value is the old string index and the second is the new string index.

4.3.2.5 #define USB_EVENT_CONNECTED

The device is now attached to a USB host and ready to begin sending and receiving data (used by device classes only).

4.3.2.6 #define USB_EVENT_DATA_REMAINING

This event is sent by a lower layer to inquire about the amount of unprocessed data buffered in the layers above. It is used in cases where a low level driver needs to ensure that all preceding data has been processed prior to performing some action or making some notification. Clients receiving this event should return the number of bytes of data that are unprocessed or 0 if no outstanding data remains.

4.3.2.7 #define USB_EVENT_DISCONNECTED

The device has been disconnected from the USB host (used by device classes only).

Note:

In device mode, the USB_EVENT_DISCONNECTED will not be reported if the MCU's PB1/USB0VBUS pin is connected to a fixed +5 Volts rather than directly to the VBUS pin on the USB connector.

4.3.2.8 #define USB_EVENT_ERROR

An error has been reported on the channel or pipe. The *ui32MsgValue* parameter indicates the source(s) of the error and is the logical OR combination of "USBERR_" flags defined below.

4.3.2.9 #define USB_EVENT_POWER_DISABLE

The controller needs power removed, This is only generated on OTG parts if automatic power control is disabled.

4.3.2.10 #define USB_EVENT_POWER_ENABLE

The controller has detected a A-Side cable and needs power applied This is only generated on OTG parts if automatic power control is disabled.

4.3.2.11 #define USB_EVENT_POWER_FAULT

The host detected a power fault condition.

4.3.2.12 #define USB_EVENT_REQUEST_BUFFER

This event is sent by a lower layer supporting DMA to request a buffer in which the next received packet may be stored. The *ui32MsgValue* parameter indicates the maximum size of packet that can be received in this channel and *pvMsgData* points to storage which should be written with the returned buffer pointer. The return value from the callback should be the size of the buffer allocated (which may be less than the maximum size passed in *ui32MsgValue* if the client knows that fewer bytes are expected to be received) or 0 if no buffer is being returned.

4.3.2.13 #define USB_EVENT_RESUME

The bus has left suspend state.

4.3.2.14 #define USB_EVENT_RX_AVAILABLE

Data has been received and is in the buffer provided or is ready to be read from the FIFO. If the *pvMsgData* value is 0 then the *ui32MsgParam* value contains the amount of data in bytes ready to be read from the device. If the *pvMsgData* value is not 0 then *pvMsgData* is a pointer to the data that was read and *ui32MsgParam* is the number of valid bytes in the array pointed to by *pvMsgData*.

4.3.2.15 #define USB_EVENT_SCHEDULER

A scheduler event has occurred.

4.3.2.16 #define USB_EVENT_SOF

A start of frame event has occurred. This event is disabled by default and must be enabled via a call from the application to USBHCDEventEnable().

4.3.2.17 #define USB_EVENT_STALL

A device or host has detected a stall condition.

4.3.2.18 #define USB_EVENT_SUSPEND

The bus has entered suspend state.

4.3.2.19 #define USB_EVENT_TX_COMPLETE

Data has been sent and acknowledged. If this event is received via the USB buffer callback, the *ui32MsgValue* parameter indicates the number of bytes from the transmit buffer that have been successfully transmitted and acknowledged.

4.3.2.20 #define USB_EVENT_UNKNOWN_CONNECTED

An unknown device is now attached to a USB host. This value is only valid for the generic event handler and not other device handlers. It is useful for applications that want to know when an unknown device is connected and what the class is of the unknown device.
The *ui32Instance* is the device instance for the unknown device.

4.4 USB Chapter 9 Definitions

Data Structures

- struct tConfigDescriptor
- struct tDescriptorHeader
- struct tDeviceDescriptor
- struct tDeviceQualifierDescriptor
- struct tEndpointDescriptor
- struct tInterfaceDescriptor
- struct tString0Descriptor
- struct tStringDescriptor
- struct tUSBRequest

Defines

- #define NEXT_USB_DESCRIPTOR(ptr)
- #define USB3Byte(ui32Value)
- #define USBLong(ui32Value)
- #define USBShort(ui16Value)

4.4.1 Detailed Description

This section describes the various data structures and labels relating to standard USB descriptors and requests as defined in chapter 9 of the USB 2.0 specification. These definitions can be found in `usblib.h`.

For ease of use alongside the USB specification, members of the structures defined here are named to according to the equivalent field in the USB documentation. Note that this convention departs from the naming convention applied to all other Texas Instruments data types.

It is important to be aware that all the structures described in this section are byte packed. Appropriate typedef modifiers are included in `usblib.h` to ensure the correct packing for all currently-supported toolchains.

The USB 2.0 specification may be downloaded from the USB Implementers Forum (USB-IF) web site at http://www.usb.org/developers/docs/.

4.4.2 Define Documentation

4.4.2.1 #define NEXT_USB_DESCRIPTOR(ptr)

Traverse to the next USB descriptor in a block.

Parameters:

ptr points to the first byte of a descriptor in a block of USB descriptors.

This macro aids in traversing lists of descriptors by returning a pointer to the next descriptor in the list given a pointer to the current one.

Returns:

Returns a pointer to the next descriptor in the block following *ptr*.

4.4.2.2 #define USB3Byte(ui32Value)

Write a 24-bit value to a USB descriptor block.

Parameters:

ui32Value is the 24-bit value that to write to the descriptor.

This helper macro is used in descriptor definitions to write three-byte values. Since the configuration descriptor contains all interface and endpoint descriptors in a contiguous block of memory, these descriptors are typically defined using an array of bytes rather than as packed structures.

Returns:

Not a function.

4.4.2.3 #define USBLong(ui32Value)

Write a 32-bit value to a USB descriptor block.

Parameters:

ui32Value is the 32-bit value that to write to the descriptor.

This helper macro is used in descriptor definitions to write four-byte values. Since the configuration descriptor contains all interface and endpoint descriptors in a contiguous block of memory, these descriptors are typically defined using an array of bytes rather than as packed structures.

Returns:

Not a function.

4.4.2.4 #define USBShort(ui16Value)

Write a 16-bit value to a USB descriptor block.

Parameters:

ui16Value is the 16-bit value to write to the descriptor.

This helper macro is used in descriptor definitions to write two-byte values. Since the configuration descriptor contains all interface and endpoint descriptors in a contiguous block of memory, these descriptors are typically defined using an array of bytes rather than as packed structures.

Returns:

Not a function.

4.5 USB Buffer and Ring Buffer APIs

Data Structures

- struct tUSBBuffer
- struct tUSBRingBufObject

Defines

- #define USB_BUFFER_WORKSPACE_SIZE

Typedefs

- typedef uint32_t(∗) tUSBPacketAvailable (void ∗pvHandle)
- typedef uint32_t(∗) tUSBPacketTransfer (void ∗pvHandle, uint8_t ∗pi8Data, uint32_t ui32Length, bool bLast)

Functions

- void ∗ USBBufferCallbackDataSet (tUSBBuffer ∗psBuffer, void ∗pvCBData)
- uint32_t USBBufferDataAvailable (const tUSBBuffer ∗psBuffer)
- void USBBufferDataRemoved (const tUSBBuffer ∗psBuffer, uint32_t ui32Length)
- void USBBufferDataWritten (const tUSBBuffer ∗psBuffer, uint32_t ui32Length)
- uint32_t USBBufferEventCallback (void ∗pvCBData, uint32_t ui32Event, uint32_t ui32MsgValue, void ∗pvMsgData)
- void USBBufferFlush (const tUSBBuffer ∗psBuffer)
- void USBBufferInfoGet (const tUSBBuffer ∗psBuffer, tUSBRingBufObject ∗psRingBuf)
- const tUSBBuffer ∗ USBBufferInit (tUSBBuffer ∗psBuffer)
- uint32_t USBBufferRead (const tUSBBuffer ∗psBuffer, uint8_t ∗pui8Data, uint32_t ui32Length)
- uint32_t USBBufferSpaceAvailable (const tUSBBuffer ∗psBuffer)
- uint32_t USBBufferWrite (const tUSBBuffer ∗psBuffer, const uint8_t ∗pui8Data, uint32_t ui32Length)
- void USBBufferZeroLengthPacketInsert (const tUSBBuffer ∗psBuffer, bool bSendZLP)
- void USBRingBufAdvanceRead (tUSBRingBufObject ∗psUSBRingBuf, uint32_t ui32NumBytes)
- void USBRingBufAdvanceWrite (tUSBRingBufObject ∗psUSBRingBuf, uint32_t ui32NumBytes)

- uint32_t USBRingBufContigFree (tUSBRingBufObject *psUSBRingBuf)
- uint32_t USBRingBufContigUsed (tUSBRingBufObject *psUSBRingBuf)
- bool USBRingBufEmpty (tUSBRingBufObject *psUSBRingBuf)
- void USBRingBufFlush (tUSBRingBufObject *psUSBRingBuf)
- uint32_t USBRingBufFree (tUSBRingBufObject *psUSBRingBuf)
- bool USBRingBufFull (tUSBRingBufObject *psUSBRingBuf)
- void USBRingBufInit (tUSBRingBufObject *psUSBRingBuf, uint8_t *pui8Buf, uint32_t ui32Size)
- void USBRingBufRead (tUSBRingBufObject *psUSBRingBuf, uint8_t *pui8Data, uint32_t ui32Length)
- uint8_t USBRingBufReadOne (tUSBRingBufObject *psUSBRingBuf)
- uint32_t USBRingBufSize (tUSBRingBufObject *psUSBRingBuf)
- uint32_t USBRingBufUsed (tUSBRingBufObject *psUSBRingBuf)
- void USBRingBufWrite (tUSBRingBufObject *psUSBRingBuf, const uint8_t *pui8Data, uint32_t ui32Length)
- void USBRingBufWriteOne (tUSBRingBufObject *psUSBRingBuf, uint8_t ui8Data)

4.5.1 Detailed Description

At the lowest level, USB communication is packet-based with the size of each packet dependent upon the configuration of the USB endpoint. In addition, when a packet is in transit, no more data may be sent on that endpoint until the transmission completes so state machines are required to ensure that data is only sent when it is safe to do so.
This model is suitable for some applications but in other cases a simple read/write model allowing arbitrarily sized blocks of data to be received or transmitted at times suitable to the application is more appropriate. The USB buffer API allows an application to chose this type of operation when used in conjunction with particular host- or device-class drivers.
A USB buffer provides a unidirectional buffer for a single endpoint and may be configured for operation as either a receive buffer (accepting data from the USB controller and passing it to an application) or a transmit buffer (accepting data from the application and passing it to the USB controller for transmission). In each case, the buffer handles all packetization or depacketization of data and allows the application to read or write arbitrarily-sized blocks of data (subject to the space limitations in the buffer, of course) at times suitable to it.
Each USB buffer makes use of a ring buffer object to store the buffered data. The ring buffer object is not USB-specific and does not interact directly with any USB drivers but the API is made available since the functionality may be useful to an application in areas outside USB communication, for example to buffer data from a UART or other peripheral. If attempting to buffer a USB data stream, however, the USB buffer API should be used since it handles the USB driver-side interaction on behalf of the application. An application must not mix calls to the two APIs for the same object - if using a USB buffer, only APIs of the form USBBufferXxx() should be used to access that buffer and, similarly, if using a plain ring buffer, only USBRingBufXxx() calls must be used.
Source for the USB buffer and ring buffer functions can be found in files `usbbuffer.c` and `usbringbuf.c`. Header file `usblib.h` contains prototypes and data type definitions for these functions.

4.5.2 Using USB Buffers

The USB buffer object is designed to allow insertion between a USB device class driver and the device application or between the USB host controller driver and a host class driver in an application- and class-independent way. Driver data transfer APIs all use a common

prototype as do event callbacks so the USB buffer is inserted into the data path using driver function and instance pointers provided in static structures during application initialization. This method has the advantage that the USB buffer is not directly dependent upon any specific functions in the USB library and, as a result, using it does not pull extraneous code into the final application image.
During operation, events from the layer below the buffer are inspected in the buffer's event handler. If they are unrecognized or have no effect on the flow of data, they are passed to the higher layer unaltered. If they relate to data flow, however, the buffer intercepts them and performs the necessary actions to transmit or receive data before passing appropriate events to the layer above.
To insert a buffer for use on a transmit or receive channel or pipe, a `tUSBBuffer` structure must be initialized as follows.

`bTransmitBuffer` This field must be set to true if the buffer is passing data from the application code to the USB controller or false if passing data from the USB controller to the application.

`pfnCallback` This field should point to the event handler callback function in the application code. Notifications of asynchronous events relating to the buffer will be made by calls to this function.

`pvCBData` The callback data pointer written to this field will be passed as the first parameter on all future calls to the application event handler (set in pfnCallback). Typically an application will set this pointer to some value allowing it easy access to data associated with the channel, for example a pointer to an internal instance data structure. The actual content is application specific and the USB buffer merely stores the value and passes it back to the caller when required.

`pfnTransfer` This field informs the USB buffer of the function to call whenever data is to be transferred between the buffer and the lower layer. This is used to transmit a packet of data if this is a transmit buffer (bTransmitBuffer set to true) or to receive a packet of data if this is a receive buffer (bTransmitBuffer set to false). Taking the example of a buffer used to transmit data to the USB generic bulk device class driver, this would be set to point to USBDBulkPacketWrite(). A receive buffer used with the same driver would have this field set to point to USBDBulkPacketRead().

`pfnAvailable` For a transmit buffer, this function pointer must be set to point to the lower layer function that can be called to determine whether the relevant USB endpoint or pipe is ready to accept a new packet for transmission. For a receive buffer, this field points to the function that should be called to determine the size of buffer required to read a newly-received packet. Using the same example, a transmit buffer above the USB generic bulk device class driver would have this field set to point to USBDBulkTxPacketAvailable() and a receive buffer above the same driver would set the field to point to USBDBulkRxPacketAvailable().

pvHandle	This field must be set to the handle which should be passed as the first parameter to the functions provided in pfnTransfer and pfnAvailable. This will typically be a pointer to the instance structure for the lower layer object in use. In the case of the USB generic bulk device class, this would be the tUSBDBulkDevice pointer originally passed to (and returned from) USBDBulkInit().
pcBuffer	This field must be initialized to point to the block of RAM that will be used to buffer data on this channel. The buffer will be managed as a ring buffer. If the application wishes to access the buffer directly rather than via the USBBufferRead() and USBBufferWrite() APIs (thus avoiding a copy operation), it is vital to ensure that ring wrap conditions are correctly handled in the application code.
ulBufferSize	This field provides the size of the buffer pointed to by pcBuffer in bytes.
pvWorkspace	The USB buffer requires a block of RAM in which it can store state variables. This field points to application-supplied RAM that can be used as workspace by the buffer object. This RAM must not be accessed by the application and must remain accessible to the USB buffer for as long as the buffer exists (between calls to USBBufferInit() and USBBufferTerm()). The label USB_BUFFER_WORKSPACE_SIZE defines the number of bytes of workspace required.

Once a transmit buffer is initialized, the application can write data to it using function USBBufferWrite() whenever space is available and the USB buffer driver will handle packet transmission to the lower layer. Similarly USBBufferRead() can be called to read received data from a receive buffer at any time. In both cases, the USB buffer uses the same event protocol that the lower layers use to indicate to the application when more data can be transferred or when data has been sent. When data from the USB controller is added to a receive buffer, USB_EVENT_RX_AVAILABLE is passed to the application and when data is removed from a transmit buffer after having been sent to the lower layer, USB_EVENT_TX_COMPLETE is sent.
Applications `usb_dev_bulk` and `usb_dev_serial` provide examples of how to use USB buffers in a device application.

4.5.3 Define Documentation

4.5.3.1 #define USB_BUFFER_WORKSPACE_SIZE

The number of bytes of workspace that each USB buffer object requires. This workspace memory is provided to the buffer on USBBufferInit() in the *pvWorkspace* field of the *tUSBBuffer* structure.

4.5.4 Typedef Documentation

4.5.4.1 typedef uint32_t(*) tUSBPacketAvailable(void *pvHandle)

A function pointer type which describes either a class driver transmit or receive packet available function (both have the same prototype) to the USB buffer object.
Parameters:
pvHandle is the handle of the device.

Returns:
None.

4.5.4.2 typedef uint32_t(*) tUSBPacketTransfer(void *pvHandle, uint8_t *pi8Data, uint32_t ui32Length, bool bLast)

A function pointer type which describes either a class driver packet read or packet write function (both have the same prototype) to the USB buffer object.

4.5.5 Function Documentation

4.5.5.1 void* USBBufferCallbackDataSet (tUSBBuffer * *psBuffer*, void * *pvCBData*)

Sets the callback pointer supplied to clients of this buffer.

Parameters:

psBuffer is the pointer to the buffer instance whose callback data is to be changed.

pvCBData is the pointer the client wishes to receive on all future callbacks from this buffer.

This function sets the callback pointer which this buffer will supply to clients as the *pvCBData* parameter in all future calls to the event callback.

Note:

If this function is to be used, the application must ensure that the tUSBBuffer structure used to describe this buffer is held in RAM rather than flash. The *pvCBData* value passed is written directly into this structure.

Returns:

Returns the previous callback pointer set for the buffer.

4.5.5.2 uint32_t USBBufferDataAvailable (const tUSBBuffer * *psBuffer*)

Returns the number of bytes of data available in the buffer.

Parameters:

psBuffer is the pointer to the buffer instance which is to be queried.

This function may be used to determine the number of bytes of data in a buffer. For a receive buffer, this indicates the number of bytes that the client can read from the buffer using USBBufferRead(). For a transmit buffer, this indicates the amount of data that remains to be sent to the USB controller.

Returns:

Returns the number of bytes of data in the buffer.

4.5.5.3 void USBBufferDataRemoved (const tUSBBuffer * *psBuffer*, uint32_t *ui32Length*)

Indicates that a client has read data directly out of the buffer.

Parameters:

psBuffer is the pointer to the buffer instance from which data has been read.

ui32Length is the number of bytes of data that the client has read.

This function updates the USB buffer read pointer to remove data that the client has read directly rather than via a call to USBBufferRead(). The function is provided to aid a client

wishing to minimize data copying. To read directly from the buffer, a client must call USBBufferInfoGet() to retrieve the current buffer inpsBufVarsdices. With this information, the data following the current read index can be read. Once the client has processed much data as it needs, USBBufferDataRemoved() must be called to advance the read pointer past the data that has been read and free up that section of the buffer. The client must take care to correctly handle the wrap point if accessing the buffer directly.

Returns:

None.

4.5.5.4 void USBBufferDataWritten (const tUSBBuffer * *psBuffer*, uint32_t *ui32Length*)

Indicates that a client has written data directly into the buffer and wishes to start transmission.

Parameters:

psBuffer is the pointer to the buffer instance into which data has been written.

ui32Length is the number of bytes of data that the client has written.

This function updates the USB buffer write pointer and starts transmission of the data in the buffer assuming the lower layer is ready to receive a new packet. The function is provided to aid a client wishing to write data directly into the USB buffer rather than using the USBBufferWrite() function. This may be necessary to control when the USB buffer starts transmission of a large block of data, for example.

A transmit buffer will immediately send a new packet on any call to USBBufferWrite() if the underlying layer indicates that a transmission can be started. In some cases this is not desirable and a client may wish to write more data to the buffer in advance of starting transmission to the lower layer. In such cases, USBBufferInfoGet() may be called to retrieve the current ring buffer indices and the buffer accessed directly. Once the client has written all data it wishes to send (taking care to handle the ring buffer wrap), it should call this function to indicate that transmission may begin.

Returns:

None.

4.5.5.5 uint32_t USBBufferEventCallback (void * *pvCBData*, uint32_t *ui32Event*, uint32_t *ui32MsgValue*, void * *pvMsgData*)

Called by the USB buffer to notify the client of asynchronous events.

Parameters:

pvCBData is the client-supplied callback pointer associated with this buffer instance.

ui32Event is the identifier of the event being sent. This will be a general event identifier of the form **USBD_EVENT_xxxx** or a device class-dependent event of the form **USBD_CDC_EVENT_xxx** or **USBD_HID_EVENT_xxx**.

ui32MsgValue is an event-specific parameter value.

pvMsgData is an event-specific data pointer.

This function is the USB buffer event handler that applications should register with the USB device class driver as the callback for the channel which is to be buffered using this buffer.

Note:

This function will never be called by an application. It is the handler that allows the USB buffer to be inserted above the device class driver or host pipe driver and below the application to offer buffering support.

Returns:

The return value is dependent upon the event being processed.

4.5.5.6 void USBBufferFlush (const tUSBBuffer * *psBuffer*)

Flushes a USB buffer, discarding any data that it contains.

Parameters:

psBuffer is the pointer to the buffer instance which is to be flushed.

This function discards all data currently in the supplied buffer without processing (transmitting it via the USB controller or passing it to the client depending upon the buffer mode).

Returns:

None.

4.5.5.7 void USBBufferInfoGet (const tUSBBuffer * *psBuffer*, tUSBRingBufObject * *psRingBuf*)

Returns the current ring buffer indices for this USB buffer.

Parameters:

psBuffer is the pointer to the buffer instance whose information is being queried.

psRingBuf is a pointer to storage that will be written with the current ring buffer control structure for this USB buffer.

This function is provided to aid a client wishing to write data directly into the USB buffer rather than using the USBBufferWrite() function. This may be necessary to control when the USBBuffer starts transmission of a large block of data, for example.

A transmit buffer will immediately send a new packet on any call to USBBufferWrite() if the underlying layer indicates that a transmission can be started. In some cases this is not desirable and a client may wish to wishes to write more data to the buffer in advance of starting transmission to the lower layer. In such cases, this function may be called to retrieve the current ring buffer indices and the buffer accessed directly. Once the client has written all data it wishes to send, it should call function USBBufferDataWritten() to indicate that transmission may begin.

Returns:

None.

4.5.5.8 const tUSBBuffer* USBBufferInit (tUSBBuffer * *psBuffer*)

Initializes a USB buffer object to be used with a given USB controller and device or host class driver.

Parameters:

psBuffer points to a structure containing information on the buffer memory to be used and the underlying device or host class driver whose data is to be buffered. This structure must remain accessible for as long as the buffer is in use.

This function is used to initialize a USB buffer object and insert it into the function and callback interfaces between an underlying driver and the application. The caller supplies information on both the RAM to be used to buffer data, the type of buffer to be created (transmit or receive) and the functions to be called in the lower layer to transfer data to or from the USB controller.

Returns:

Returns the original buffer structure pointer if successful or NULL if an error is detected.

4.5.5.9 uint32_t USBBufferRead (const tUSBBuffer * *psBuffer*, uint8_t * *pui8Data*, uint32_t *ui32Length*)

Reads a block of data from a USB receive buffer into storage supplied by the caller.

Parameters:

psBuffer is the pointer to the buffer instance from which data is to be read.

pui8Data points to a buffer into which the received data will be written.

ui32Length is the size of the buffer pointed to by pui8Data.

This function reads up to *ui32Length* bytes of data received from the USB host into the supplied application buffer. If the receive buffer contains fewer than *ui32Length* bytes of data, the data that is present will be copied and the return code will indicate the actual number of bytes copied to *pui8Data*.

Returns:

Returns the number of bytes of data read.

4.5.5.10 uint32_t USBBufferSpaceAvailable (const tUSBBuffer * *psBuffer*)

Returns the number of free bytes in the buffer.

Parameters:

psBuffer is the pointer to the buffer instance which is to be queried.

This function returns the number of free bytes in the buffer. For a transmit buffer, this indicates the maximum number of bytes that can be passed on a call to USBBufferWrite() and accepted for transmission. For a receive buffer, it indicates the number of bytes that can be read from the USB controller before the buffer will be full.

Returns:

Returns the number of free bytes in the buffer.

4.5.5.11 uint32_t USBBufferWrite (const tUSBBuffer * *psBuffer*, const uint8_t * *pui8Data*, uint32_t *ui32Length*)

Writes a block of data to the transmit buffer and queues it for transmission to the USB controller.

Parameters:

psBuffer points to the pointer instance into which data is to be written.

pui8Data points to the first byte of data which is to be written.

ui32Length is the number of bytes of data to write to the buffer.

This function copies the supplied data into the transmit buffer. The transmit buffer data will be packetized according to the constraints imposed by the lower layer in use and sent to the USB controller as soon as possible. Once a packet is transmitted and acknowledged, a **USB_EVENT_TX_COMPLETE** event will be sent to the application callback indicating the number of bytes that have been sent from the buffer.

Attempts to send more data than there is space for in the transmit buffer will result in fewer bytes than expected being written. The value returned by the function indicates the actual number of bytes copied to the buffer.

Returns:

Returns the number of bytes actually written.

4.5.5.12 void USBBufferZeroLengthPacketInsert (const tUSBBuffer * *psBuffer*, bool *bSendZLP*)

Enables or disables zero-length packet insertion.

Parameters:

psBuffer is the pointer to the buffer instance whose information is being queried.

bSendZLP is **true** to send zero-length packets or **false** to prevent them from being sent.

This function allows the use of zero-length packets to be controlled by an application. In cases where the USB buffer has sent a full (64 byte) packet and then discovers that the transmit buffer is empty, the default behavior is to do nothing. Some protocols, however, require that a zero- length packet be inserted to signal the end of the data. When using such a protocol, this function should be called with *bSendZLP* set to **true** to enable the desired behavior.

Returns:

None.

4.5.5.13 void USBRingBufAdvanceRead (tUSBRingBufObject * *psUSBRingBuf*, uint32_t *ui32NumBytes*)

Removes bytes from the ring buffer by advancing the read index.

Parameters:

psUSBRingBuf points to the ring buffer from which bytes are to be removed.

ui32NumBytes is the number of bytes to be removed from the buffer.

This function advances the ring buffer read index by a given number of bytes, removing that number of bytes of data from the buffer. If *ui32NumBytes* is larger than the number of bytes currently in the buffer, the buffer is emptied.

Returns:

None.

4.5.5.14 void USBRingBufAdvanceWrite (tUSBRingBufObject * *psUSBRingBuf*, uint32_t *ui32NumBytes*)

Adds bytes to the ring buffer by advancing the write index.

Parameters:

psUSBRingBuf points to the ring buffer to which bytes have been added.

ui32NumBytes is the number of bytes added to the buffer.

This function should be used by clients who wish to add data to the buffer directly rather than via calls to USBRingBufWrite() or USBRingBufWriteOne(). It advances the write index by a given number of bytes.

Note:

It is considered an error if the *ui32NumBytes* parameter is larger than the amount of free space in the buffer and a debug build of this function will fail (ASSERT) if this condition is detected. In a release build, the buffer read pointer will be advanced if too much data is written but this will, of course, result in some of the oldest data in the buffer being discarded and also, depending upon how data is being read from the buffer, may result in a race condition which could corrupt the read pointer.

Returns:

None.

4.5.5.15 uint32_t USBRingBufContigFree (tUSBRingBufObject * *psUSBRingBuf*)

Returns number of contiguous free bytes available in a ring buffer.

Parameters:

psUSBRingBuf is the ring buffer object to check.

This function returns the number of contiguous free bytes ahead of the current write pointer in the ring buffer.

Returns:

Returns the number of contiguous bytes available in the ring buffer.

4.5.5.16 uint32_t USBRingBufContigUsed (tUSBRingBufObject * *psUSBRingBuf*)

Returns number of contiguous bytes of data stored in ring buffer ahead of the current read pointer.

Parameters:

psUSBRingBuf is the ring buffer object to check.

This function returns the number of contiguous bytes of data available in the ring buffer ahead of the current read pointer. This represents the largest block of data which does not straddle the buffer wrap.

Returns:

Returns the number of contiguous bytes available.

4.5.5.17 bool USBRingBufEmpty (tUSBRingBufObject * *psUSBRingBuf*)

Determines whether a ring buffer is empty or not.

Parameters:

psUSBRingBuf is the ring buffer object to empty.

This function is used to determine whether or not a given ring buffer is empty. The structure is specifically to ensure that we do not see warnings from the compiler related to the order of volatile accesses being undefined.

Returns:

Returns **true** if the buffer is empty or **false** otherwise.

4.5.5.18 void USBRingBufFlush (tUSBRingBufObject * *psUSBRingBuf*)

Empties the ring buffer.

Parameters:

psUSBRingBuf is the ring buffer object to empty.

Discards all data from the ring buffer.

Returns:

None.

4.5.5.19 uint32_t USBRingBufFree (tUSBRingBufObject * *psUSBRingBuf*)

Returns number of bytes available in a ring buffer.

Parameters:

psUSBRingBuf is the ring buffer object to check.

This function returns the number of bytes available in the ring buffer.

Returns:

Returns the number of bytes available in the ring buffer.

4.5.5.20 bool USBRingBufFull (tUSBRingBufObject * *psUSBRingBuf*)

Determines whether a ring buffer is full or not.

Parameters:

psUSBRingBuf is the ring buffer object to empty.

This function is used to determine whether or not a given ring buffer is full. The structure is specifically to ensure that we do not see warnings from the compiler related to the order of volatile accesses being undefined.

Returns:

Returns **true** if the buffer is full or **false** otherwise.

4.5.5.21 void USBRingBufInit (tUSBRingBufObject * *psUSBRingBuf*, uint8_t * *pui8Buf*, uint32_t *ui32Size*)

Initializes a ring buffer object.

Parameters:

psUSBRingBuf points to the ring buffer to be initialized.

pui8Buf points to the data buffer to be used for the ring buffer.

ui32Size is the size of the buffer in bytes.

This function initializes a ring buffer object, preparing it to store data.

Returns:

None.

4.5.5.22 void USBRingBufRead (tUSBRingBufObject * *psUSBRingBuf*, uint8_t * *pui8Data*, uint32_t *ui32Length*)

Reads data from a ring buffer.

Parameters:

psUSBRingBuf points to the ring buffer to be read from.

pui8Data points to where the data should be stored.

ui32Length is the number of bytes to be read.

This function reads a sequence of bytes from a ring buffer.

Returns:

None.

4.5.5.23 uint8_t USBRingBufReadOne (tUSBRingBufObject * *psUSBRingBuf*)

Reads a single byte of data from a ring buffer.

Parameters:

psUSBRingBuf points to the ring buffer to be written to.

This function reads a single byte of data from a ring buffer.

Returns:

The byte read from the ring buffer.

4.5.5.24 uint32_t USBRingBufSize (tUSBRingBufObject * *psUSBRingBuf*)

Returns the size in bytes of a ring buffer.

Parameters:

psUSBRingBuf is the ring buffer object to check.

This function returns the size of the ring buffer.

Returns:

Returns the size in bytes of the ring buffer.

4.5.5.25 uint32_t USBRingBufUsed (tUSBRingBufObject * *psUSBRingBuf*)

Returns number of bytes stored in ring buffer.

Parameters:

psUSBRingBuf is the ring buffer object to check.

This function returns the number of bytes stored in the ring buffer.

Returns:

Returns the number of bytes stored in the ring buffer.

4.5.5.26 void USBRingBufWrite (tUSBRingBufObject * *psUSBRingBuf*, const uint8_t * *pui8Data*, uint32_t *ui32Length*)

Writes data to a ring buffer.

Parameters:

psUSBRingBuf points to the ring buffer to be written to.

pui8Data points to the data to be written.

ui32Length is the number of bytes to be written.

This function write a sequence of bytes into a ring buffer.

Returns:

None.

4.5.5.27 void USBRingBufWriteOne (tUSBRingBufObject * *psUSBRingBuf*, uint8_t *ui8Data*)

Writes a single byte of data to a ring buffer.

Parameters:

psUSBRingBuf points to the ring buffer to be written to.

ui8Data is the byte to be written.

This function writes a single byte of data into a ring buffer.

Returns:

None.

4.6 Internal USB DMA functions

Defines

- #define USBLibDMAArbSizeSet(psUSBDMAInst, ui32Channel, ui32ArbSize)
- #define USBLibDMAChannelAllocate(psUSBDMAInst, ui8Endpoint, ui32MaxPacketSize, ui32Config)
- #define USBLibDMAChannelDisable(psUSBDMAInst, ui32Channel)
- #define USBLibDMAChannelEnable(psUSBDMAInst, ui32Channel)
- #define USBLibDMAChannelIntDisable(psUSBDMAInst, ui32Channel)
- #define USBLibDMAChannelIntEnable(psUSBDMAInst, ui32Channel)

- #define USBLibDMAChannelRelease(psUSBDMAInst, ui8Endpoint)
- #define USBLibDMAChannelStatus(psUSBDMAInst, ui32Channel)
- #define USBLibDMAIntHandler(psUSBDMAInst, ui32Status)
- #define USBLibDMAIntStatus(psUSBDMAInst)
- #define USBLibDMAIntStatusClear(psUSBDMAInst, ui32Status)
- #define USBLibDMAStatus(psUSBDMAInst)
- #define USBLibDMATransfer(psUSBDMAInst, ui32Channel, pvBuffer, ui32Size)
- #define USBLibDMAUnitSizeSet(psUSBDMAInst, ui32Channel, ui32BitSize)

Functions

- tUSBDMAInstance * USBLibDMAInit (uint32_t ui32Index)

4.6.1 Define Documentation

4.6.1.1 #define USBLibDMAArbSizeSet(psUSBDMAInst, ui32Channel, ui32ArbSize)

This function is used to set the arbitration size for a DMA channel.

Parameters:

psUSBDMAInst is the DMA instance data for a USB controller.

ui32Channel is the DMA channel number to modify.

ui32ArbSize is the transfer arbitration size in bytes.

This function configures the individual transfer size of the DMA channel provided in the *ui32Channel* parameter. The *ui32Channel* must already be allocated to an endpoint by calling the USBLibDMAChannelAllocate() function.

Returns:

None.

4.6.1.2 #define USBLibDMAChannelAllocate(psUSBDMAInst, ui8Endpoint, ui32MaxPacketSize, ui32Config)

This function is used to assign a DMA channel to an endpoint.

Parameters:

psUSBDMAInst is the DMA instance data for a USB controller.

ui8Endpoint is the endpoint number to assign a DMA channel.

ui32MaxPacketSize is the maximum packet size for the endpoint assigned that is being assigned to the DMA channel.

ui32Config are the basic configuration options for the DMA channel.

This function assigns a DMA channel to a given endpoint. The *ui8Endpoint* parameter is the zero based endpoint number that is assigned a DMA channel. The *ui32Config* parameter contains any configuration options for the DMA channel. The current options include the following:

- **USB_DMA_EP_TX** - this request is for a transmit DMA channel.
- **USB_DMA_EP_RX** - this request is for a receive DMA channel.

Note:

The maximum number of available DMA channels to endpoints varies between devices.

Returns:

Zero or the DMA channel assigned to the endpoint.

4.6.1.3 #define USBLibDMAChannelDisable(psUSBDMAInst, ui32Channel)

This function disables DMA for a given DMA channel.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

ui32Channel is the DMA channel to disable.

This function disables DMA on the channel number passed in the *ui32Channel* parameter.

Returns:

None.

4.6.1.4 #define USBLibDMAChannelEnable(psUSBDMAInst, ui32Channel)

This function enables DMA for a given channel.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

ui32Channel is the DMA channel to enable.

This function enables DMA on the channel number passed in the *ui32Channel* parameter.

Returns:

None.

4.6.1.5 #define USBLibDMAChannelIntDisable(psUSBDMAInst, ui32Channel)

This function disables DMA interrupt for a given DMA channel.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

ui32Channel is the DMA channel interrupt to disable.

This function disables the DMA interrupt on the channel number passed in the *ui32Channel* parameter.

Returns:

None.

4.6.1.6 #define USBLibDMAChannelIntEnable(psUSBDMAInst, ui32Channel)

This function enables the DMA interrupt for a given channel.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

ui32Channel is the DMA channel interrupt to enable.

This function enables DMA interrupt on the channel number passed in the *ui32Channel* parameter.

Returns:

None.

4.6.1.7 #define USBLibDMAChannelRelease(psUSBDMAInst, ui8Endpoint)

This function is used to free a DMA channel that was assigned to an endpoint.

Parameters:

psUSBDMAInst is the DMA instance data for a USB controller.

ui8Endpoint is the DMA channel number to free up.

This function frees up a DMA channel that was allocated to an endpoint by the USBLibDMAChannelAllocate() function.

Returns:

None.

4.6.1.8 #define USBLibDMAChannelStatus(psUSBDMAInst, ui32Channel)

This function returns the current DMA status for a given DMA channel.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

ui32Channel is the DMA channel number used to retrieve the DMA status.

This function returns the current status of a DMA transfer on a given DMA channel. The DMA channel is specified by the *ui32Channel* parameter.

Returns:

This function returns one of the **USBLIBSTATUS_DMA_**$*$ values.

4.6.1.9 #define USBLibDMAIntHandler(psUSBDMAInst, ui32Status)

This function is called by the USB interrupt handler.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

ui32Status is the DMA interrupt status.

This function is called by the USB interrupt handler to allow the DMA interface to handle interrupts outside of the context of the normal USB interrupt handler. The *ui32Status* is the current DMA interrupt status at the time of the USB interrupt. Since some DMA controller interrupts are cleared automatically when read, this value must be retrieved by calling the USBLibDMAIntStatus() function and passed into this function.

Returns:

None.

4.6.1.10 #define USBLibDMAIntStatus(psUSBDMAInst)

This function returns the current DMA interrupt status.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

This function returns the interrupt status for all DMA channels. The value returned is a per channel interrupt mapping with the DMA channels mapped into bits 0-31 by channel number with channel 1 starting at bit 0.

Note:

This function does not return an endpoint interrupt status, but the interrupt status for the DMA interface used with the USB controller.

Returns:

This function returns the pending DMA interrupts.

4.6.1.11 #define USBLibDMAIntStatusClear(psUSBDMAInst, ui32Status)

This function clears the requested DMA interrupt status.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

ui32Status contains the interrupts to clear.

This function clears the current DMA interrupt status for the controller specified by the *ui32Instance* parameter. The *ui32Status* value has the same format as the value returned from the USBLibDMAIntStatus() function which is a per channel interrupt mapping. The DMA channels are mapped into bits 0-31 by channel number with channel 1 starting at bit 0.

Returns:

None.

4.6.1.12 #define USBLibDMAStatus(psUSBDMAInst)

This function is used to return any global status information for USB DMA.

Parameters:

psUSBDMAInst is a generic instance pointer that can be used to distinguish between different hardware instances.

This function performs returns the global status for the USB DMA interface.

Returns:

Always returns 0.

4.6.1.13 #define USBLibDMATransfer(psUSBDMAInst, ui32Channel, pvBuffer, ui32Size)

This function is configures a USB transfer on a given DMA channel.

Parameters:

psUSBDMAInst is the DMA structure pointer for this instance.

ui32Channel is the DMA channel to use.

pvBuffer is a pointer to the buffer to use for the transfer.

ui32Size is the size of the data to be transferred in bytes.

This function is called to configure a transfer using the USB controller depending on the parameters. The *ui32Channel* parameter holds the channel number to use for this transfer which must have already been allocated with a call to the USBLibDMAChannelAllocate() function. The transaction is configured to transfer *ui32Size* bytes to/from the buffer held in the *pvBuffer* pointer.

Returns:

This function returns the number of bytes scheduled to be transferred.

4.6.1.14 #define USBLibDMAUnitSizeSet(psUSBDMAInst, ui32Channel, ui32BitSize)

This function is used to set the individual transfer size of a DMA channel.

Parameters:

psUSBDMAInst is the DMA instance data for a USB controller.

ui32Channel is the DMA channel number to modify.

ui32BitSize is the individual transfer size in bits(8, 16 or 32).

This function configures the individual transfer size of the DMA channel provided in the *ui32Channel* parameter. The *ui32Channel* must already be allocated to an endpoint by calling the USBLibDMAChannelAllocate() function. The *ui32BitSize* parameter should be on of the following values: 8, 16 or 32.

Returns:

None.

4.6.2 Function Documentation

4.6.2.1 tUSBDMAInstance * USBLibDMAInit (uint32_t *ui32Index*)

This function is used to initialize the DMA interface for a USB instance.

Parameters:

ui32Index is the index of the USB controller for this instance.

This function performs any initialization and configuration of the DMA portions of the USB controller. This function returns a pointer that is used with the remaining USBLibDMA APIs or the function returns zero if the requested controller cannot support DMA. If this function is called when already initialized it will not reinitialize the DMA controller and will instead return the previously initialized DMA instance.

Returns:

A pointer to use with USBLibDMA APIs.

5 Dual Mode Functions

5.1 Introduction

Dual mode.

Source Code Overview

Source code and headers for the device specific USB functions can be found in the device directory of the USB library tree, typically `libraries/communications/usb/f2838x/include/device` and `libraries/communications/usb/f2838x/source/device`.

`usbdevice.h`	The header file containing device mode function prototypes and data types offered by the library. This file is the main header file defining the USB Device API.
`usbdbulk.h`	The header file defining the USB generic bulk device class driver API.
`usbdcdc.h`	The header file defining the USB Communication Device Class (CDC) device class driver API.
`usbdhid.h`	The header file defining the USB Human Interface Device (HID) device class driver API.
`usbdhidkeyb.h`	The header file defining the USB HID keyboard device class API.
`usbdhidmouse.h`	The header file defining the USB HID keyboard device class API.
`usbdenum.c`	The source code for the USB device enumeration functions offered by the library.
`usbdhandler.c`	The source code for the USB device interrupt handler.
`usbdconfig.c`	The source code for the USB device configuration functions.
`usbdcdesc.c`	The source code for functions used to parse configuration descriptors defined in terms of an array of sections (as used with the USB Device API).
`usbdbulk.c`	The source code for the USB generic bulk device class driver.
`usbdcdc.c`	The source code for the USB Communication Device Class (CDC) device class driver.
`usbdhid.c`	The source code for the USB Human Interface Device (HID) device class driver.

`usbdhidkeyb.c`	The source code for the USB HID keyboard device class.
`usbdhidmouse.c`	The source code for the USB HID keyboard device class.
`usbdevicepriv.h`	The private header file containing definitions shared between various source files in the device directory. Applications must not include this header.

5.2 Dual Mode APIs

Functions

- void USBDualModeInit (uint32_t ui32Index)
- void USBDualModeTerm (uint32_t ui32Index)

5.2.1 Detailed Description

Dual Mode APIs

5.2.2 Function Documentation

5.2.2.1 USBDualModeInit

Initializes the USB controller for dual mode operation.

Prototype:

```
void
USBDualModeInit(uint32_t ui32Index)
```

Parameters:

ui32Index specifies the USB controller that is to be initialized for dual mode operation. This parameter must be set to 0.

Description:

This function initializes the USB controller hardware into a state suitable for dual mode operation. Applications may use this function to ensure that the controller is in a neutral state and able to receive appropriate interrupts before host or device mode is chosen using a call to USBStackModeSet().

Returns:

None.

5.2.2.2 USBDualModeTerm

Returns the USB controller to the default mode when in dual mode operation.

Prototype:

```
void
USBDualModeTerm(uint32_t ui32Index)
```

Parameters:

ui32Index specifies the USB controller whose dual mode operation is to be ended. This parameter must be set to 0.

Description:

Applications using both host and device modes may call this function to disable interrupts in preparation for shutdown or a change of operating mode.

Returns:

None.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DLP® Products	www.dlp.com	Broadband	www.ti.com/broadband
DSP	dsp.ti.com	Digital Control	www.ti.com/digitalcontrol
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Military	www.ti.com/military
Logic	logic.ti.com	Optical Networking	www.ti.com/opticalnetwork
Power Mgmt	power.ti.com	Security	www.ti.com/security
Microcontrollers	microcontroller.ti.com	Telephony	www.ti.com/telephony
RFID	www.ti-rfid.com	Video & Imaging	www.ti.com/video
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265