USB Communication

What is USB?

- Universal Serial Bus
- Low-Speed, Full-Speed, High-Speed: 1.5, 12, and 480 MBps
- Host-initiated Transfers
- Four transfer types: Control, Isochronous, Interrupt, Bulk
- Two transfer directions: IN & OUT (host-centric)

Control Transfers

- Typically used by USB system software to query, configure, and issue certain generic commands to USB devices.

- In PSoC, don't need to worry about these.

Isochronous Transfers

- Guaranteed latency & bandwidth transfer
- Sorta like UDP (no error checking/correction)
- For use when data delivery time is more important than accuracy
- 0-1023 bytes per transfer with Full-speed USB

Interrupt Transfers

- Used to poll devices at regular intervals
- Typically for devices which transmit a small amount of data (mice, keyboards, etc.)
- Can also be used to signal that other endpoints have data available.
- 0-64 bytes per transfer with full-speed USB

Bulk Transfers

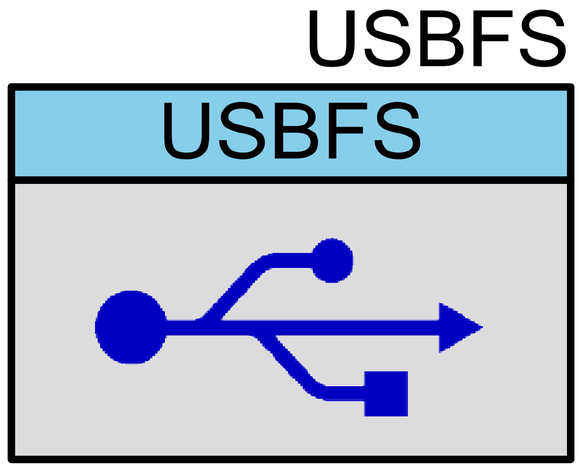
- Most common transfer you will use.
- 0-64 bytes per transfer with full-speed USB
- error checking
- given low priority on the bus, but generally works pretty quick

Transfer Limits

- USB divides transfers into “frames”.
- Each frame is 1 ms.
- One transaction per endpoint, per frame.
- Max bandwidth for full speed bulk endpoint = 64 bytes * 1000 = 64Kb/s.
- High-speed usb is considerably faster, as it divides each frame into 8 “microframes”, and allows for much 512 byte transfers in each microframe, allowing for 512*8*1000 = 4 MB/s.

PSoC USB Component

Full speed USB
Support for all 4 transfer types
512 Bytes of endpoint memory
8 Endpoints (IN or OUT or mixture of both)



Major API Components

- **USBFS_Start**
  - Starts the USB component
- **USBFS_GetEPState(uint8 epNumber)**
  - Returns state of given USB endpoint

Return Value	Description
USBFS_NO_EVENT_PENDING	The endpoint is awaiting SIE action
USBFS_EVENT_PENDING	The endpoint is awaiting CPU action
USBFS_NO_EVENT_ALLOWED	The endpoint is locked from access
USBFS_IN_BUFFER_FULL	The IN endpoint is loaded and the mode is set to ACK IN
USBFS_IN_BUFFER_EMPTY	An IN transaction occurred and more data can be loaded
USBFS_OUT_BUFFER_EMPTY	The OUT endpoint is set to ACK OUT and is waiting for data
USBFS_OUT_BUFFER_FULL	An OUT transaction has occurred and data can be read

- **USBFS_LoadInEP(uint8 epNumber, uint8 *pData, uint16 length)**
  - Loads an IN Endpoint with a data array
- **USBFS_ReadOutEP(uint8 epNumber, uint8 *pData, uint16 length)**
  - Reads data from an OUT Endpoint to a data array.

IN Data flow

- PSoC checks if endpoint status is USB_IN_BUFFER_EMPTY
- PSoC loads an IN buffer with data, API sets status flag to USB_IN_BUFFER_FULL automatically
- HOST Issues an IN transaction
- PSoC USB SIE (Serial Interface Engine) responds to transaction without CPU intervention
- Endpoint status flag is set to USB_IN_BUFFER_EMPTY
- repeat....

OUT Data flow

- HOST Issues an OUT transaction
- PSoC USB SIE (Serial Interface Engine) responds to transaction without CPU intervention, sets endpoint status flag to USB_OUT_BUFFER_FULL
- PSoC checks if endpoint status is USB_OUT_BUFFER_FULL
- PSoC reads data from OUT buffer, API sets status flag to USB_OUT_BUFFER_EMPTY automatically
- repeat....

USB on the PC side

- Libraries:
  - libusb-1.0 -- best option I have found so far for cross-platform USB.
  - CyUSB -- windows-only USB driver provided by Cypress

- Finding Devices:
  - VID/PID (Vendor ID, Product ID), uniquely identifies device.
  - format is 4 hex characters per ID: 0xFFFF/0xFFFF
  - Vendor IDs are licensed by USB Consortium (but you don't need a license to use a random one)

USB on the PC side

- Device Descriptors
  - Table of configuration data that tells the PC what capabilities the USB device has
    - Includes number of endpoints, type of endpoints
    - Can have multiple configurations of descriptors
- USB Device Classes
  - Standardized USB Class Descriptors that allow the Operating system to interface with a device without needing a custom driver
    - Examples: Mice, Keyboards, some sound cards

libusb-1.0

- C library
- Cross-platform: Mac, Linux, Windows.
- python integration with PyUSB
- other language wrappers exist as well, (.NET, etc.)

libusb-1.0 synchronous API

- libusb_bulk_transfer(
  struct libusb_device_handle * dev_handle,
  unsigned char endpoint,
  unsigned char * data,
  int length,
  int * transferred,
  unsigned int timeout
)

USB Endpoint conventions

- Usually written in hex.
- PSoC can handle 8 endpoints
- MSB indicates direction of endpoint:
  - 0x81-0x88 = IN Endpoints
  - 0x01-0x08 = OUT Endpoints

Assignment

- Build an application on the PSoC to send some data via USB to your PC or Mac.
- Data can be potentiometer data, button state, whatever.
- Make it do something useful! (volume control, hide browser windows, etc.)

Resources

libusb-1.0 API: http://libusb.sourceforge.net/api-1.0/index.html

LibUSBDotNET: http://libusbdotnet.sourceforge.net/V2/Index.html

For windows: ZADIG Driver installer:
https://sourceforge.net/projects/libwdi/files/zadig/

USB Overview (needs VPN)
http://proquest.safaribooksonline.com/book/-/9781435457867/usb-an-overview/ch02