14.7. Universal Serial Bus (USB)

General References

http://www.usb.org.

http://www.beyondlogic.org/usbnutshell/

USB References

http://www.ftdichip.com/Documents/ProgramGuides/D2XXPG34.pdf

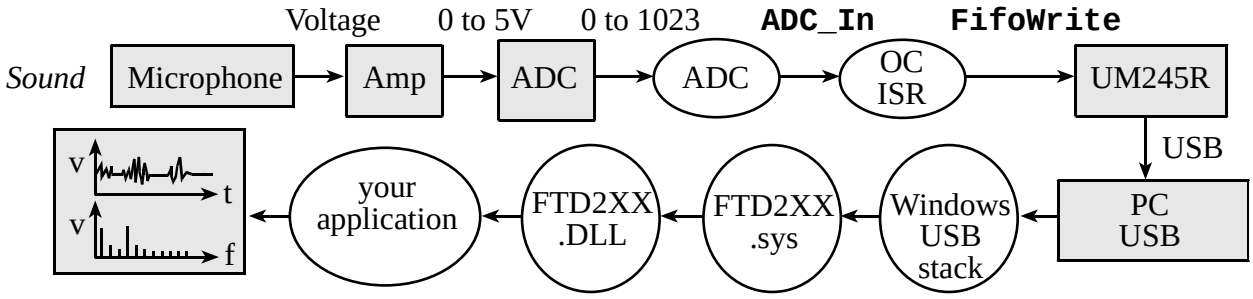
http://www.ftdichip.com/Drivers/D2XX.htm

http://www.ftdichip.com/Documents/InstallGuides/Windows_XP_Installation_Guide.pdf

http://www.dlpdesign.com/test.shtml

http://www.ftdichip.com/Projects/CodeExamples.htm

http://www.dlpdesign.com/drivers/D2XXPG21.pdf



Old Lab 4.1. Data-flow graph of the digital scope and spectrum analyzer.

Specifications

Short distance (typically less than 4 meters)

USB 2.0 supports three speeds.

- High Speed - 480Mbits/s
- Full Speed - 12Mbits/s
- Low Speed - 1.5Mbits/s

One host per bus (at a time)

- all transactions and scheduling bandwidth

Token-based protocol

Tiered star topology (Host-centered)

Hub provides power

- Monitors power
- Switching off a device drawing too much current
- Filter out high speed and full speed transactions

7-bit address, up to 127 devices can be connected

Host loads and unloads drives automatically

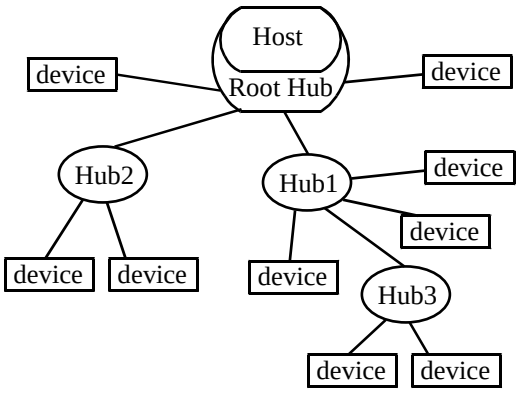


Figure 14.31. USB network topology.

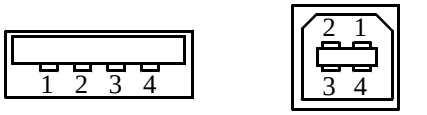
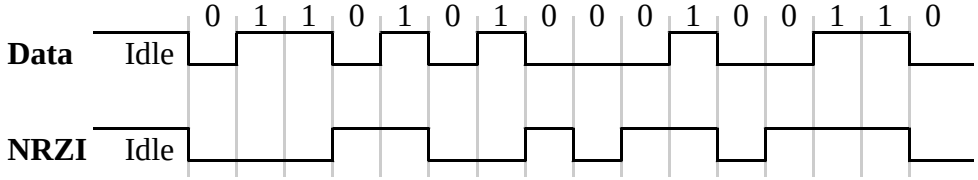


Figure 7.18. USB connectors.

Pin Number	Color	Function
1	Red	VBUS (5 V)
2	White	D-
3	Green	D+
4	Black	Ground

Table 7.5. USB signals.

The D+ and D- are twisted pair differential data
Non Return to Zero Invert (NRZI) encoding
1 is represented by no change in level
0 is represented by a change in level
String of zeros causes the NRZI data to toggle each bit time
String of ones causes long periods with no transitions in the data
Bit stuffing ensures transitions to which the receiver can synchronize
0 inserted after 6 consecutive 1's
1 inserted after 6 consecutive 0's



The USB architecture comprehends four basic types of data transfers:

- **Control Transfers**: Used to configure a device
- **Bulk Data Transfers**: Large quantities and wide latitude in constraints.
- **Interrupt Data Transfers**: Used for timely but reliable delivery of data.
- **Isochronous Data Transfers**: Prenegotiated bandwidth
  Prenegotiated latency
  Streaming real time transfers
  Audio or video applications
  Stream pipe
  Unidirectional

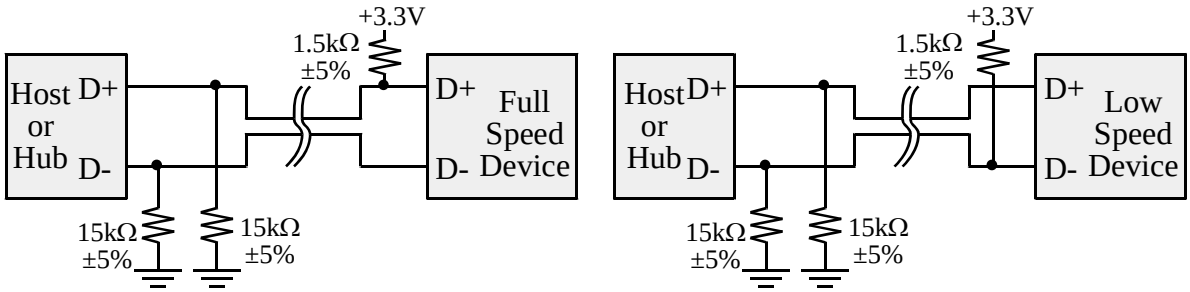


Figure 14.32. Pull-up resistors on USB devices signal specify the speed.

Each USB transaction consists of three packets

- **Token Packet** (header),
- **Optional Data Packet**, (information) and
- **Status Packet** (acknowledge)

Token Packet	Sync	PID	ADDR	ENDP	CRC5	EOP
Data Packet	Sync	PID	Data		CRC16	EOP
Handshake Packet	Sync	PID	EOP			
Start of Frame	Sync	PID	Frame Number		CRC5	EOP

Figure 14.33. USB packet types.

USB **functions** provide a capability
Printer, Thumb Drive, Scanner, Modem or your 9S12.

Endpoints are sources or sinks of data (buffers within the device)
Host can send data to an endpoint
Device puts data in endpoint, but it is not transferred until host requests it

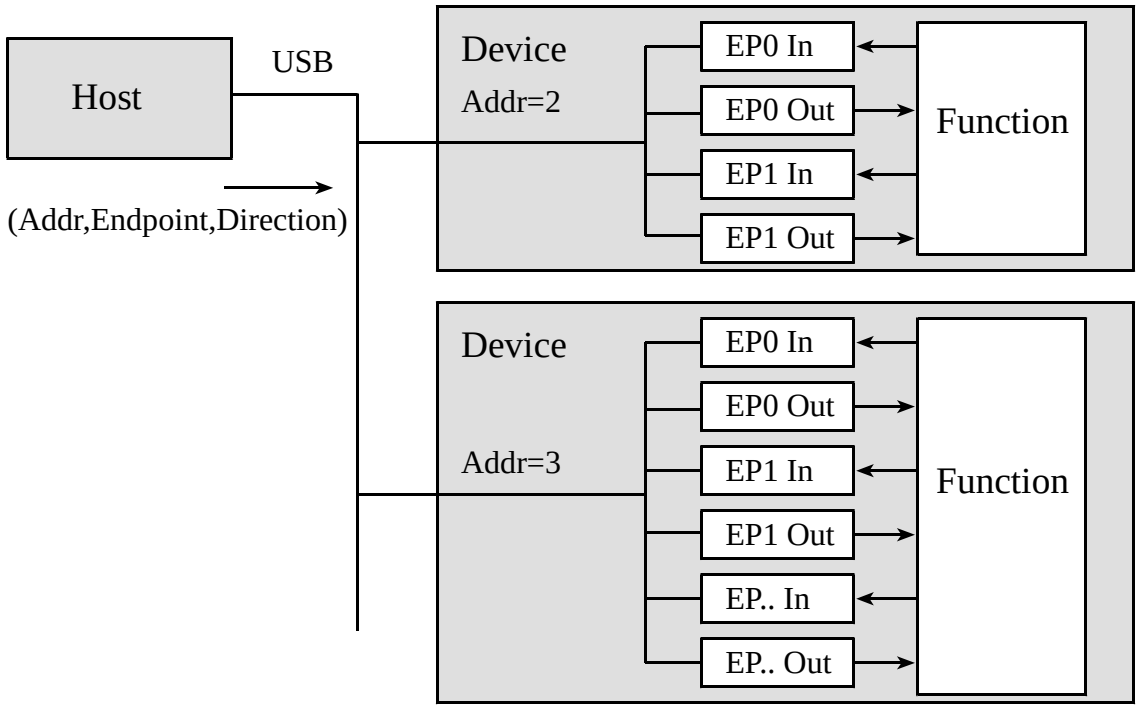


Figure 14.34. USB data flow model.

pipe is a logical connection between the host and endpoint(s).
how much bandwidth
what transfer type (Control, Bulk, Iso or Interrupt)
direction of data flow
maximum packet/buffer sizes

Stream Pipes can be used send unformatted data.
Data flows sequentially
pre-defined direction, either in or out.
bulk, isochronous and interrupt transfer types
controlled by the host or device

Message Pipes have a
defined USB format
host-controlled
Data is then transferred in the desired direction
support control transfers.

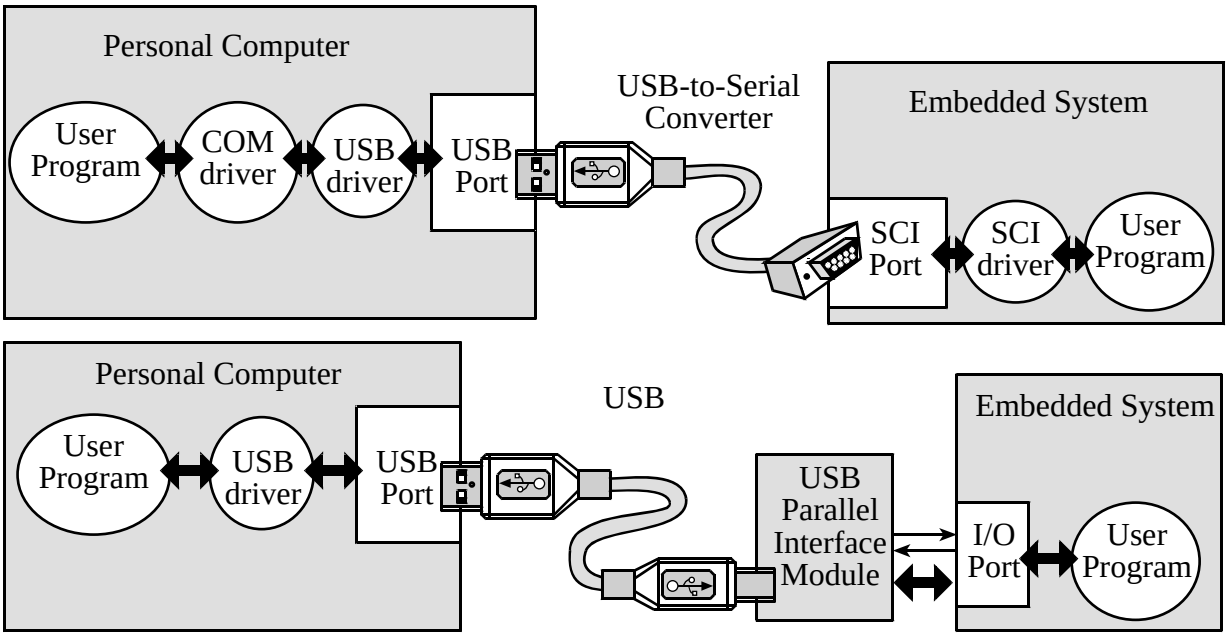


Figure 14.35. Modular approach to USB interfacing.

14.7.2. Modular USB interface

USB-to-serial converters

IOGear Inc.	http://www.iogear.com
Wyse Technology	http://www.wyse.com
D-Link Corporation	http://www.dlink.com
Computer Peripheral Sys, Inc.	http://www.cpscom.com
Jo-Dan International, Inc.	http://www.jditech.com

USB parallel interface module.

send and receive data using parallel handshake protocols
Include a USB-enabled interface and receiver/transmit FIFO buffers
more flexible than the serial cable method,
    the microcontroller module can be tailored
    USB drivers can be tailored
burn PID and VID numbers into EEPROM.
data is unformatted
does not implement high bandwidth bulk transfers
does not negotiate for real-time bandwidth with isochronous data transfers.

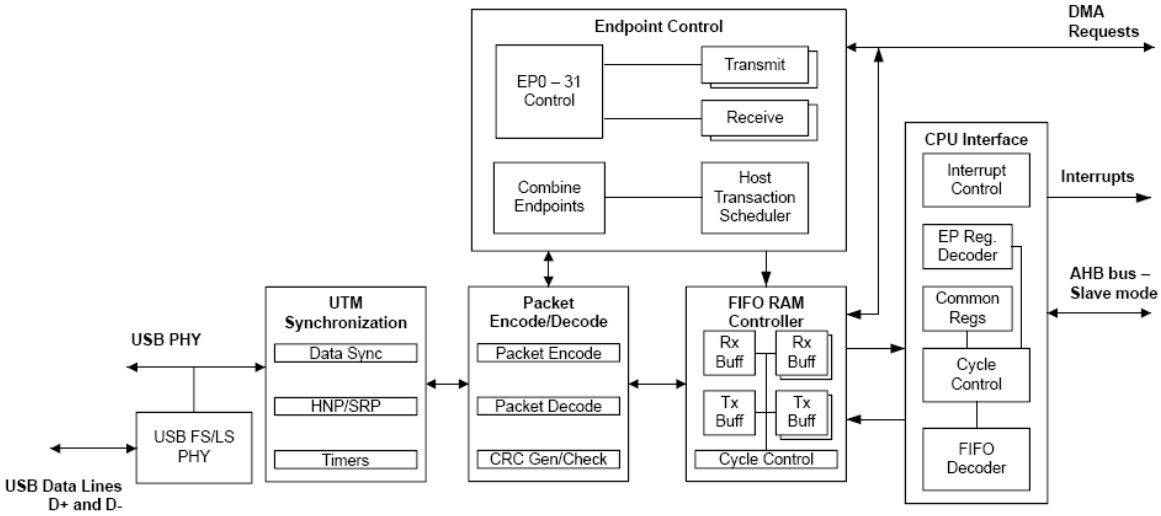
Companies that make these modules include

Future Tech. Devices Inter. Ltd.	http://www.ftdichip.com/
ActiveWire, Inc.	http://www.activewireinc.com
DLP Design, Inc.	http://www.dlpdesign.com
Elexol Pty Ltd.	http://www.elexol.com

14.7.3. Integrated USB interface

LM3S5651

Figure 18-1. USB Module Block Diagram

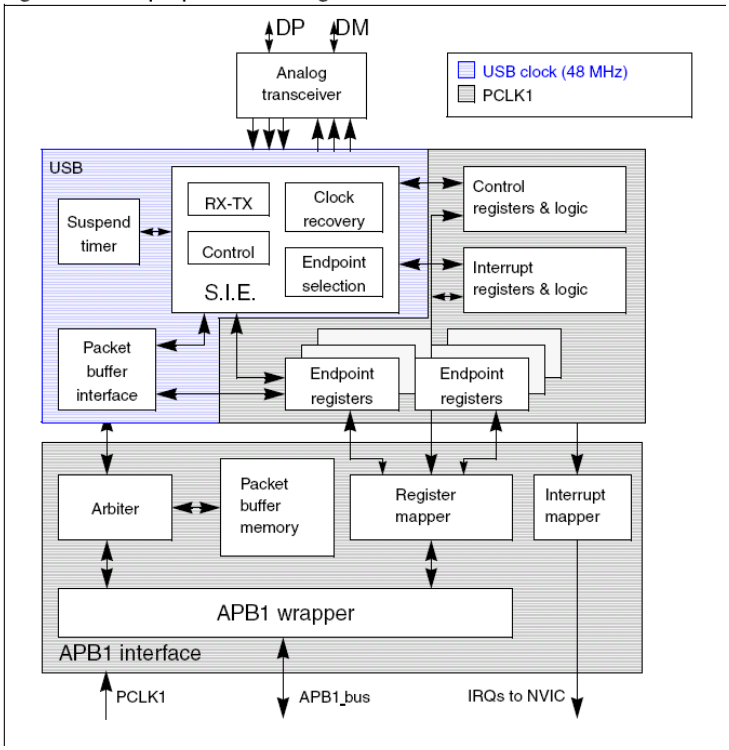


- Microchip PIC18F2455
- FTDI FT245BM
- Freescale 9S12UF32
- STM32F103

2.3.20 Universal serial bus (USB)

The STM32F103xx performance line embeds a USB device peripheral compatible with the USB full-speed 12 Mbs. The USB interface implements a full-speed (12 Mbit/s) function interface. It has software-configurable endpoint setting and suspend/resume support. The dedicated 48 MHz clock is generated from the internal main PLL (the clock source must use a HSE crystal oscillator).

Figure 191. USB peripheral block diagram



Similarities of USB and CAN

- Local wired network
- Serial
- Half-duplex
- Differential pair, voltage encoded
- Microcontroller hardware support (built-in I/O functions)
- Short distances (same box, same room)
- Bit stuffing

Differences between USB and CAN

- CAN is distributed, USB is host-controller
- USB bandwidth is higher
- CAN can have more nodes
- USB is powered, CAN is not powered
- USB has negotiated speed, CAN is fixed speed
- USB is addressed by destination, CAN has data types

- USB typically used to connect microcontroller to PC/Mac