Choosing the Right Device for Your USB Application

Introduction

This application note guides the USB designer through the process of determining the most suitable Cypress USB chip for their product. With the widest portfolio of USB chips, Cypress Semiconductor has a device for almost every application.

USB can be a daunting new technology for designers not familiar with its details. Most designers will only need to become familiar in detail with the parts of the USB Specification that are relevant to their application. To avoid the requirement for designers to familiarize themselves with the whole USB Specification simply in order to determine what kind of device will be required in their application, this application note takes designers through the process of determining whether they require a device with Host, Hub or Peripheral functionality. It also helps designers decide whether their application requires Low, Full or High Speed signaling.

Step #1 - Host, Hub or Peripheral?

Every USB system must have one and only one "host" - that is, a bus "master." USB does not support a peer-peer topology. A host is said to have a "downstream" port—that is a port to which peripherals ("slaves") can be connected either directly or via one or more hubs. The host initiates all USB traffic—either by transmitting data itself, or requesting data from a device on the bus. USB host controllers are typically PCI bus devices, controlled via the PCI bus by a powerful microprocessor; most PC chipsets now include an integrated USB host controller. But what happens when the PC is removed from the system and the application requires a USB host in a Set-top box or PDA/Cell-phone? Cypress recognizes the paradigm shift towards an embedded host market and offers the SL811HS/T as a solution. To learn more about the SL811HS/T, turn to the "Cypress USB Embedded Host Selection Guide" section of this application note.

A USB Hub is a "repeating" device that allows multiple downstream peripherals to be connected to a single upstream host or hub port. The USB specification permits up to 5 "tiers" of hubs between a peripheral and a host. A hub cannot originate downstream traffic on its downstream ports itself—all downstream data traffic is simply retransmission of data the hub has received on its upstream port. In addition, a hub is required to behave in a similar manner to a peripheral on its upstream port, as the hub controller function can itself be regarded as a peripheral. Note that it is possible to have a hub function and an independent peripheral function implemented in the same device—for example a monitor or keyboard hub. To select the USB hub device that is right for your application, please refer to the "Cypress Hub Device Selection Guide" section of this application note.

A Peripheral has one and only one "upstream" port—that is a port by which the device is connected to the downstream port of a host, either directly or via one or more hubs. A peripheral never transmits data without first receiving a request from the host to do so. To select the USB peripheral device that is right for your application, proceed to step #2.

Step #2 - Low-Speed, Full-Speed, or High-Speed Peripheral?

USB has 3 data rates: "low-speed," "full-speed," and "high-speed." The signaling rates are 1.5 Mbps, 12 Mbps and 480 Mbps respectively, but these rates do not accurately reflect the data throughput available to a single device using that signaling rate.

For low-speed signaling, the best guaranteed throughput is 8 bytes of payload data every 10 ms, per endpoint—which is 6400 bps. Comparing this to RS-232 with 1 start, 1 stop and 1 parity bits with continuous transmission (no handshaking) this is equivalent to 8800 baud on a traditional serial link. Low-Speed devices can have up to 2 data endpoints, so by using 2 endpoints a single USB device may achieve an RS-232 equivalent data throughput of 17600 baud.

If this data throughput is adequate for your application. refer to the "Cypress Low-Speed USB Peripheral Device Selection Guide" section of this application note.

For full-speed signaling, the payload data throughput is limited only by the 12-Mbps signaling rate and the protocol overhead. The maximum data throughput available shared between all devices connected to a single USB host is 1.216 MB/s—equivalent to 9.728 Mbps. It is only possible for a single device to "reserve" up to 90% of this bandwidth using "interrupt" or "Isochronous" transfers (please refer to the USB specification for details). Sustained data throughputs of 8.7 Mbps have been demonstrated, even using Cypress's lowest specification AN21xx Full-Speed device. However in general, in cases where bandwidth requirements approach the full-speed limit, it is recommended that High-Speed signaling be selected.

If this data throughput is adequate for your application, refer to the "Cypress Full-Speed USB Peripheral Device Selection Guide" section of this application note; otherwise, refer to the "Cypress High-Speed Peripheral Device Selection Guide" section of this application note.

Device Selection Decision Tree

```
Host? ──Yes──────────────────────────► See Cypress USB
  │                                      Embedded Host
  No                                     Selection Guide
  ▼
Hub? ──Yes──────────────────────────► See Cypress USB
  │                                      Hub Device
  No                                     Selection Guide
  ▼
Peripheral? ──Yes──► Low Speed? ──Yes──► See Cypress Low
                          │               Speed Peripheral
                          No              Device Selection
                          ▼               Guide
                     Full Speed? ──Yes──► See Cypress Full
                          │               Speed Peripheral
                          No              Device Selection
                          ▼               Guide
                     High Speed? ──Yes──► See Cypress High
                                          Speed Peripheral
                                          Selection Guide
```
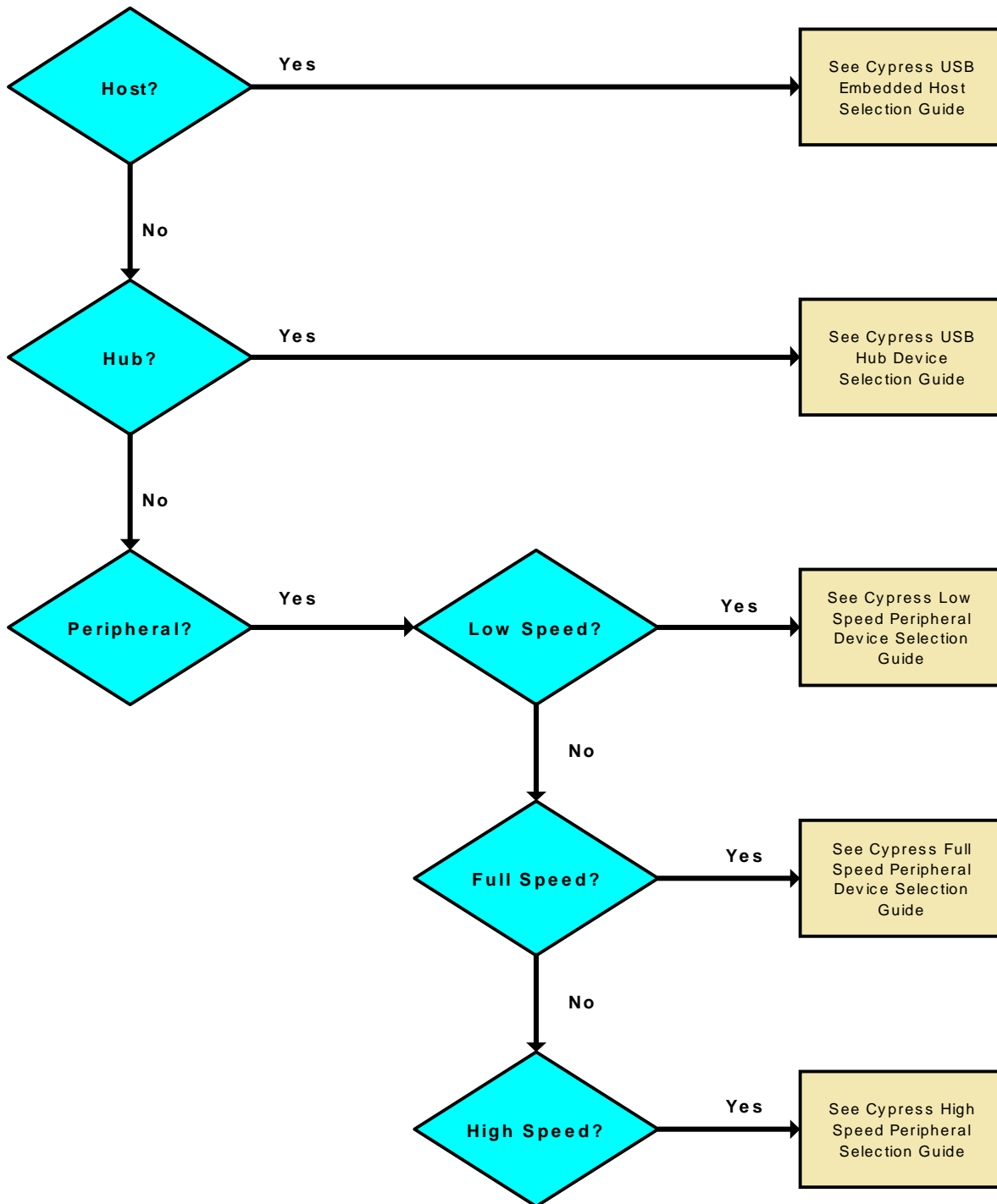
Cypress USB Embedded Host Selection Guide

For host applications, Cypress offers the SL811HS/T for use in a variety of embedded applications such as PDAs, Set-top Boxes, MP3 players, etc. The host/slave functionality provides support for both full and low speed devices in host mode and the SL811HS/T switches automatically to slave mode when a connection to a USB host is detected. The SL811HS interfaces to any CPU or bus, thus allowing you to choose any microprocessor that best suits your application. Support for a variety of microprocessors and operating systems is available including VxWorks, Linux, and Windows® CE.

Table 1. Cypress USB Embedded Host Selection Guide

	SL811HS	**SL811HST**
RAM (Bytes)	256	256
EPROM (KBytes)	N/A	N/A
Number of I/Os	N/A	N/A
Package Type	28-pin PLCC	48-pin LQFP
Interface	Memory-mapped or Programmed I/O	Memory-mapped or Programmed I/O
Development Kit	SL811HS/T DVK	SL811HS/T DVK

Cypress USB Hub Device Selection Guide

Cypress offers a broad family of full-speed USB devices for hub applications ideally suited for integrated keyboard, motherboard and monitor hubs. Also included in Cypress's USB hub device family are stand alone USB hubs (up to 7 downstream ports). The OTP PROM-based solution provides high flexibility, thus enabling fast time to market.

Cypress has also announced *TetraHub*™ (CY7C65640), a high-performance standalone Universal Serial Bus (USB) hub controller, compliant with the USB 2.0 Specification. Cypress's innovative 'Tetra' architecture provides four downstream USB ports and four "Transaction Translators" (TT), making it the highest performance hub available. This self-contained device features an integrated SIE, hub controller, hub repeater, four transaction translators, and USB data transceivers. *TetraHub* is a fixed-function solution, requiring no firmware intervention, thereby reducing design risk and development time. *TetraHub* can improve time-to-market in a number of USB 2.0 designs, including standalone hubs, motherboard hubs, and monitor hubs.

TetraHub is a self-powered USB 2.0 hub device. Power management for all downstream ports supports power switching and overcurrent detection with individual or ganged control. The four downstream ports support High Speed, Full Speed and Low Speed devices. Four individual transaction translators have been implemented, providing full 12 Mbps performance to each full-speed downstream port, whereas single transaction translator designs must split the Full Speed bandwidth between all USB 1.1 peripherals attached to the hub. *TetraHub* has a Serial Peripheral Interface (SPI) communication block, allowing easy implementation in a number of USB hub applications, while also allowing for user customization of vendor and product IDs. Cypress has also integrated the 1.5KOhm pull-up resistor on the D+ line which is required for connect/disconnect detection on the upstream USB port.

Table 2. Cypress USB Hub Device Selection Guide

	CY7C65X13	CY7C66X13	CY7C65100	CY7C65640
Typical Applications	4-port Standalone USB Hub 7-port Standalone USB Hub	USB Peripheral + 4-port USB Hub	Fixed-function 4-port USB Standalone Hub	4-port USB 2.0 Hub
EPROM	8 KB	8 KB	N/A	N/A
I/Os	11-22	29-31	Supports ganged and individual port power switching, as well as bus powered and self-powered.	Supports ganged and individual port power switching
Package Types Also available in bare die form; volume restrictions apply[1]	28-pin PDIP/SOIC 48-pin PDIP/SSOP	48-pin PDIP 48-pin SSOP 56-pin SSOP	28-pin SOIC	56-pin QFN
Development Kit	CY3654 + CY3654-P03	CY3654 + CY3654-P03	N/A	N/A

Note:

1. Contact your local Cypress sales representative for more details.

4

Cypress Low-Speed Peripheral Device Selection Guide

Cypress's low-speed USB device family offers powerful, flexible, integrated solutions for a wide range of USB applications. The devices feature the industry's smallest 8-bit RISC core with RAM, OTP PROM, USB logic, and a USB transceiver all integrated into a single device.

Cypress's latest line of Low Speed devices is the enCoRe™ (enhanced Component Reduction) family, featuring a range of USB chips with a patent pending internal oscillator that removes the requirement for any external resonator or crystal. Other components commonly found in low-speed USB applications such as pull-up resistors, wake-up circuitry, and a 3.3V regulator have also been integrated into the chip to provide an overall reduction in system cost.

Table 3. Cypress Low-Speed Peripheral Device Selection Guide

	CY7C630/1XXA	CY7C634/5XX\	CY7C636XX	enCoRe™ (CY7C632XXA)	enCoRe (CY7C637XX)
Typical Applications	Keyboards, Mice, Joysticks, Universal Power Supplies	Keyboards, Mice, Joysticks, Universal Power Supplies	Keyboards, Mice, Joysticks, Universal Power Supplies	Standard USB Mouse, USB Wheel Mouse, Combination USB-PS2 Mouse	Optical Mouse, Wireless Mouse, Combination USB-PS2 Mouse
RAM (Bytes)	128	256	256	96	256
OTP PROM (KBytes)	2/4	4/6/8	6/8	3	6/8
Number of I/Os	12-16	32-40	16	8-10	10-16
Endpoints	2	3	3	2	3
Resonator	External	External	External	Internal/External[2]	Internal/External[2]
PS/2 Support?	No	Yes	Yes	Yes	Yes
Package Types	20-pin PDIP 20-pin SOIC 24-pin SOIC 24-pin QSOP	40-pin PDIP 48-pin SSOP 40-pin CerDIP 48-pin SideBraze	24-pin SOIC	16-pin PDIP 18-pin PDIP 18-pin SOIC	18-pin PDIP 18-pin SOIC 24-pin PDIP 24-pin SOIC
Development Kit	CY3650	CY3654 + CY3654-P02	CY3654 + CY3654-P02	CY3654 + CY3654-PO5	CY3654 + CY3654-PO5

Note:

2. External resonator is optional.

Cypress Full-Speed USB Peripheral Device Selection Guide

For full-speed applications such as printers, scanners, xDSL modems, and digital cameras, Cypress offers a broad range of solutions. Cypress offers unique architectures that will give peripheral developers the freedom and flexibility to choose the solution that best fits their needs.

The CY64x13 range of full-speed USB devices is based on the same architecture as the low-speed and hub devices, and offers a simple and straightforward firmware migration path from these products.

The EZ-USB® range of full-speed USB devices is a richly featured family of devices with a patented RAM-based code storage architecture that allows the easiest-possible in-field upgrading of product firmware. The firmware can be easily upgraded via download through USB. EZ-USB provides significant improvements over other USB architectures including an enhanced 8051 core, 4 or 8 Kbytes of RAM, an intelligent USB core, and high-performance I/O ports.

The EZ-USB FX™ family showcases the highest performance Full Speed USB device available on the market, and offers a simple and straightforward upgrade path to High Speed applications. The EZ-USB FX builds on the EZ-USB feature set, including an intelligent USB core, enhanced 8051, 8 KB of RAM, and high-performance I/O. The CY7C646xx enhances the EZ-USB family by providing faster operation and more ways to transfer data into and out of the chip at very high data rates. The new "faster, extended" EZ-USB FX family maintains code compatibility with EZ-USB and many of the original family's characteristics. EZ-USB FX expands the feature set that has made EZ-USB a popular choice for high-performance, highly integrated USB applications, adding super fast I/O, direct memory access (DMA), slave FIFOs and a general programmable interface (GPIF) engine. The internal FIFOs can be configured for 8- or 16-bit datapaths, and can be mastered by the EZ-USB FX or external logic. The GPIF can be configured to provide a glueless to ASICs, DSPs, or standard interfaces such as ATAPI, UTO-PIA, EPP (enhanced parallel port), wireless LAN chip sets, Home PNA chip sets, etc. The interface possibilities are endless.

Table 4. Cypress Full-Speed Peripheral USB Device Selection Guide

	CY7C64x13	EZ-USB (AN21XX)	EZ-USB FX (CY7C646XX)
Typical Applications	Analog Modems, Fingerprint Scanners, Bar code reader	MP3 Players, Scanners, Printers, Cameras	DSL Modems, Memory card readers, ATAPI Interface, Networking
Microcontroller	8 bit RISC (M8)	Enhanced 8051	Enhanced 8051
Microcontroller Speed (MHz)	12	12, 24	24, 48
Number of I/Os	19-36	16-24	16-40
Max I/O Rate	64 KB/s	2 MB/s (Burst)	96 MB/s (Burst)
Firmware Memory	8k OTP PROM	4 or 8k of RAM	4 or 8k of RAM
Datapath	8-bit	8-bit	8- or 16-bit
Data Transfer Mode	Micro Instructions	Turbo Mode	DMA
Parallel Interface	HAPI	Standard 8-bit I/F	Programmable (GPIF), Slave FIFOs
Serial Interface	I^2C-compatible	I^2C-compatible, 2 UARTs	I^2C-compatible, 2 UARTs
Number of Endpoints	5 configurable endpoints	32	32
Max. Bulk Endpoint Size	32	64	64
Max. Isochronous Endpoint Size	32	1024	1024
Package	28-pin SOIC 28-pin PDIP 48-pin SSOP	44-pin PQFP 48-pin TQFP 80-pin PQFP	52-pin PQFP 80-pin PQFP 128-pin PQFP
Development Kit	CY3654-P03	AN2131-DK001	CY3671

Cypress High-Speed USB Peripheral Selection Guide

The CY7C68013 is Cypress Semiconductor's first generation high-speed USB peripheral device and is an integrated USB 2.0 solution that fully utilizes the bandwidth capabilities of USB 2.0. The FX2™ family offers higher performance and a higher level of integration than the previous EZ-USB products, including a 40x jump to a 480 Mbits/sec signaling rate. The FX2 builds on the EZ-USB FX device by providing USB 2.0 support with an integrated transceiver, smart SIE, enhanced 8051 microcontroller, and a memory and programmable I/O interface. The CY7C68001 is Cypress Semiconductor's USB Serial Interface Engine for High Speed USB 2.0 peripheral designs. EZ-USB SX2™ is a high-performance, yet extremely cost-effective solution that integrates a USB 2.0 transceiver, a "smart" SIE, a high-speed PLL, four highly configurable endpoints sharing a 4KB FIFO space, and a very simple local bus interface. EZ-USB FX2 and SX2 can both operate at both high speed or full speed.

Table 5. Cypress High Speed USB Peripheral Selection Guide

	CY7C68013	CY7C68001
Microcontroller	Enhanced 8051	N/A
Microcontroller Speed (MHz)	12/24/48 (Firmware Selectable)	N/A
Number of I/Os	24-40	N/A
Max I/O Rate	96MB/S (Burst)	N/A
Firmware Memory	8KB	N/A
Datapath	8- or 16-bit	8- or 16-bit
Data Transfer Mode	Auto Transfer (max USB 2.0 bandwidth)	Auto Transfer (max USB 2.0 bandwidth)
Parallel Interface	Programmable (GPIF), Slave FIFOs	Slave FIFOs
Serial Interface	I²C-compatible, 2 UARTs	I²C-compatible
Number of Endpoints	7 (3 fixed, 4 large configurable endpoints)	5 (1 fixed, 4 large configurable endpoints)
Max. Bulk Endpoint Size	512 Bytes	512 Bytes
Max. Isochronous Endpoint Size	1024 Bytes	1024 Bytes
Package	56-pin SSOP 100-pin TQFP 128-pin TQFP	56-pin SSOP
Development Kit	CY3681	CY3682

Conclusion

Cypress offers the industry's broadest line of Universal Serial Bus (USB) devices and the development tools to support them. Cypress's USB devices facilitate the design of low-speed and full-speed peripherals, USB hubs, and other systems that communicate via the USB standard.

Cypress is the No. 1 USB supplier, having shipped more than 50 million USB controllers, over half of all units currently in use. Cypress has also taken aggressive steps to ensure leadership in the new high-speed USB 2.0 standard, which sup-

ports 480-Mbps transfer rates, and is putting its stamp on the USB embedded host market with the SL811HS/T.

Cypress brings your designs to life with a broad line of USB products, from silicon to development tools to programming support, as well as offering "best-in-class" applications support. Contact USB Applications for fast and comprehensive support. Also visit www.cypress.com, your gateway to the latest information on Cypress silicon products and other collateral such as development kits, programming tools, and reference designs. For pricing and availability information, contact your local Cypress sales representative. For your nearest location, visit www.cypress.com/contacts/offices.

TetraHub, enCoRe, EZ-USB FX, FX2, and SX2 are trademarks and EZ-USB is a registered trademark of Cypress Semiconductor Corporation. Windows is a registered trademark of Microsoft Corporation. All products and company names mentioned in this document may be the trademarks or registered trademarks of their respective holders.

approved dsg 4/5/02