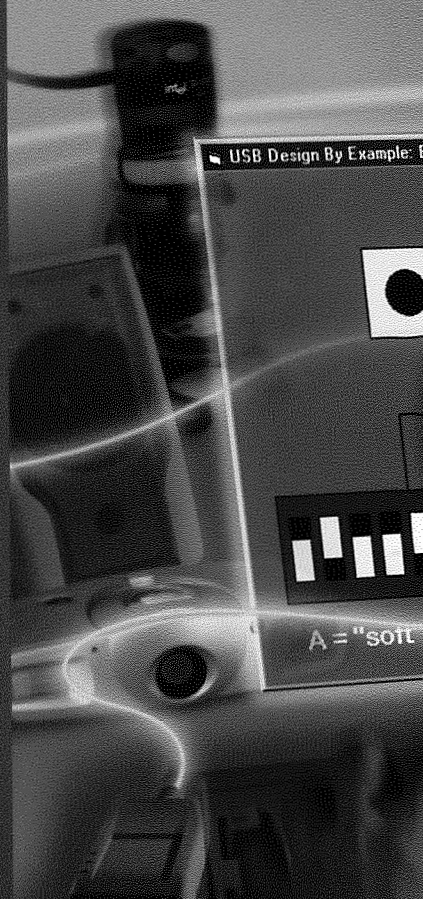


USB Design

A Practical Guide
John Hyde

Intel
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*The PC Platform
Designers' Choice*



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USB Design by Example

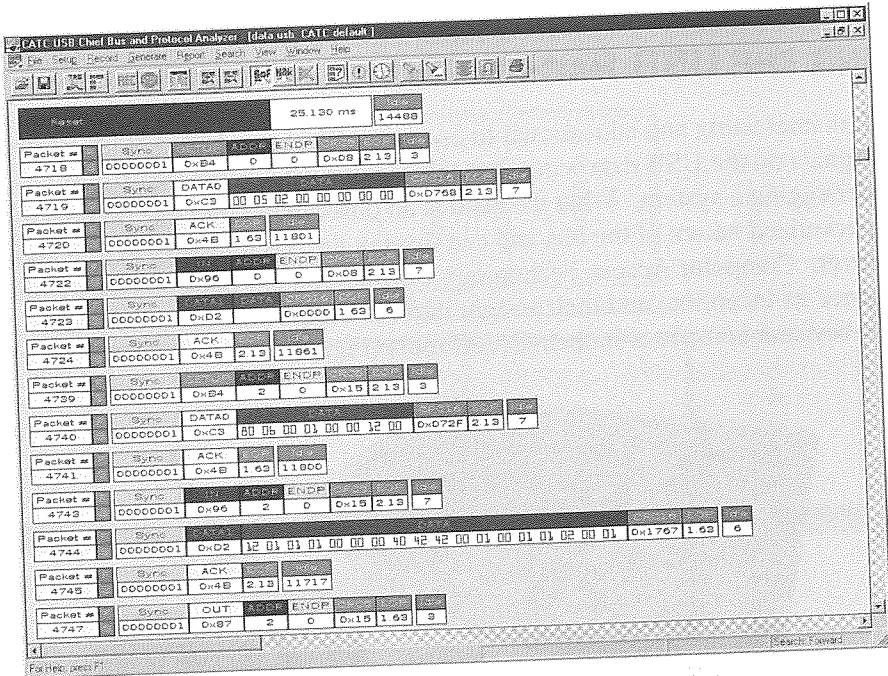


Figure 2-17. USB packets displayed as packets

All of the CATC tools capture bus activity for later analysis. The use of color to display different packet types and the grouping of building-block packets into transactions allow the designer to quickly interpret what has happened on the bus. The simpler CATC tools capture all bus activity while the more elaborate tools have programmable capture and programmable triggers. Being able to isolate packets sent to a specific device or triggering after, for example, device 42 has received 58 DATA0 packets, aids the debugging of more sophisticated USB devices. The high-end CATC tools can also be used to generate bus traffic for device reliability testing and failure analysis.

CHAPTER SUMMARY

This chapter provided insight into the signals on the bus, the fundamental packetized nature of the bus, and the transactions used to exchange data on the bus. The PC host uses a defined set of requests to control all of the devices attached to the bus, and these devices need to respond in a defined manner. Bus observation, or “sniffer” tools as they are called, are available to monitor and analyze these low-level bus signals.

THE ENUMERATION

Let us assume that the PC host meets all of the requirements of Chapter 1, is running a USB-aware operating system, and has a USB port. This port could be on the PC host itself (or through an external hub). Now we have a new USB I/O device connected to a running system. What actually happens between the PC host and the device to deliver the many USB features?

After understanding what the PC host is doing, we can look at the general I/O device. All devices describe themselves using configuration tables. We start by looking inside the simplest of these tables. In this discussion to cover the general case. We then look at the requirements for a device.

There are many “chicken-vs.-egg” situations in USB, and some technical discussions to keep the flow of

DEVICE DETECTION

Figure 3-1 shows details about the USB cable. The cable has four wires: two power wires for Vcc and Gnd and two signal wires for D+ and D-. The cable end that attaches to the hub has a Series A connector, and the cable end that attaches to the new device is either connected directly (no connector) or has a Series B connector. Both connectors have longer power and ground connector pins to ensure that the device has good voltages before signals are applied.

The hub socket supplies Vcc and Gnd. The current limiter will initially prevent more than 100 mA from being drawn, even instantaneously, from the hub. If excess current is drawn, then the hub informs the host software of this error (see “Enumeration steps,” step 5), an error message is displayed on the PC screen, and the device is **not** configured.

Because we haven’t plugged in the I/O device yet, it is in the **unattached** state.

In Figure 3-1, note the two biasing resistors in the hub; they ensure that D+ and D- are low when no device is plugged in. There is a single biasing resistor on the device that is attached to either D+ or D-. When the USB cable is plugged in, the biasing resistor causes D+ or D- to rise above ground, and this changed voltage difference is recognized by the hub. We have detected a cable being plugged in! By convention, if the device-biasing resistor is connected to D+, we are informing the hub that this device is full speed (12 Mbps), while a biasing resistor on D- indicates a low speed (1.5 Mbps) device. Simple and effective!

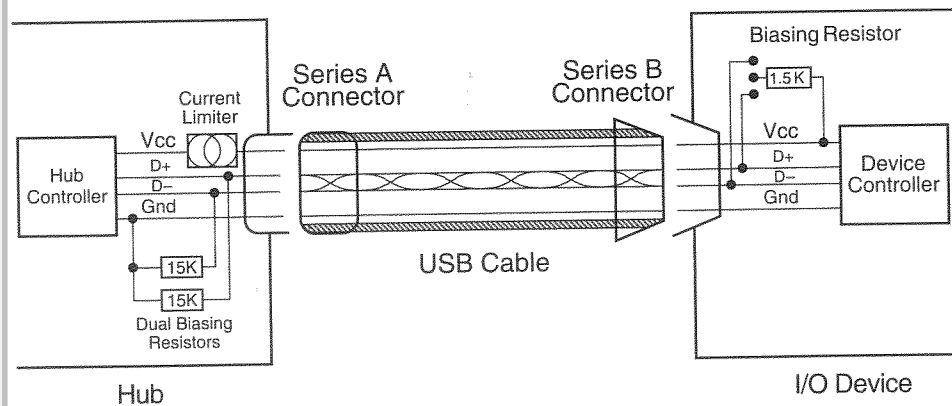


Figure 3-1. USB cable connection details

The I/O device is now in the **attached** state, and once it is configured and operational, the device moves to the **configured** state.

The hub updates a STATUS_CHANGE register for the device and then waits to be told what to do.

The PC host controls the enumeration phase and sends requests to two devices. The hub that identifies the devices receives many requests for action, and the new devices receive requests. If there are any other hubs on the bus, they will not take part in this process. They will receive requests, because that is one of their roles, but because they are not yet configured by the PC host software during this process, they do not respond.

The PC host software regularly polls all connected devices. In most cases a hub has nothing to report so when it is polled **this** time the hub responds with the STATUS_CHANGE register that the port has had a change in status—the PC host software has begun!

ENUMERATION STEPS

In the following description the PC host is initiating the enumeration process. **ToHub:** prefix if the addressed device is the hub; **FromHub:** prefix if the addressed device is the newly attached I/O device.

1. **ToHub:Get_Port_Status:** Host discovers the device.
2. **ToHub:Clear_Port_Feature(C_PORT_CHANGE):** The hub updates the STATUS_CHANGE register that status has changed.
3. **ToHub:Set_Port_Feature(PORT_RESET):** The hub sends a reset to the I/O device. The hub maintains the reset for 10 milliseconds. It then updates the RESET register and enables the PORT_ENABLE bit in the PORT_STATUS register. The next register update causes an update to the STATUS_CHANGE register. The PC host will notice this on its next scheduled poll.
4. **ToHub:Get_Port_Status:** The PC host discovers the device.

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