

Includes **USB 2.0**

USB COMPLETE

SECOND EDITION



*Everything You
Need to Develop
Custom USB
Peripherals*

With firmware tips & host code
in Visual Basic and Visual C++

JAN AXELSON

author of *Parallel Port Complete* and *Serial Port Complete*

USB Complete

Everything You Need
to Develop Custom USB Peripherals

Second Edition

Jan Axelson

Lakeview Research
Madison, WI 53704

copyright 2001 by Jan Axelson. All rights reserved.
Published by Lakeview Research
Cover by Rattray Design. Cover Photo by Bill Bilsley Photography.
Index by Broccoli Information Management

Lakeview Research
5310 Chinook Ln.
Madison, WI 53704
USA

Phone: 608-241-5824
Fax: 608-241-5848
Email: info@Lvr.com
Web: <http://www.Lvr.com>

14 13 12 11 10 9 8 7 6 5 4 3 2 1

Products and services named in this book are trademarks or registered trademarks of their respective companies. In all instances where Lakeview Research is aware of a trademark claim, the product name appears in initial capital letters, in all capital letters, or in accordance with the vendor's capitalization preference. Readers should contact the appropriate companies for complete information on trademarks and trademark registrations. All trademarks and registered trademarks in this book are the property of their respective holders.

No part of this book, except the programs and program listings, may be reproduced in any form, or stored in a database or retrieval system, or transmitted or distributed in any form, by any means, electronic, mechanical photocopying, recording, or otherwise, without the prior written permission of Lakeview Research or the author. The programs and program listings, or any portion of these, may be stored and executed in a computer system and may be incorporated into computer programs developed by the reader.

The information, computer programs, schematic diagrams, documentation, and other material in this book are provided "as is," without warranty of any kind, expressed or implied, including without limitation any warranty concerning the accuracy, adequacy, or completeness of the material or the results obtained from using the material. *Neither the publisher nor the author shall be responsible for any claims attributable to errors, omissions, or other inaccuracies in the material in this book. In no event shall the publisher or author be liable for direct, indirect, special, incidental, or consequential damages in connection with, or arising out of, the construction, performance, or other use of the materials contained herein.*

ISBN 0-9650819-5-8

Printed and bound in the United States of America

later. And some things are repeated because they're important and relevant in more than one place.

The information in these chapters is dense. If you don't have a background in USB, you won't absorb it all in one reading. You should, however, get a feel for how USB works, and will know where to look later when you need to check the details.

The ultimate authority on the USB interface is the specification published by its sponsoring members. The specification document, titled not surprisingly, *Universal Serial Bus Specification*, is available on the USB Implementers Forum's website (www.usb.org). However, by design, the specification omits information and tips that are unique to any operating system or controller chip. This type of information is essential when you're designing a product for the real world, so I've included it.

Transfer Basics

You can divide USB communications into two categories, depending on whether they're used in configuring and setting up the device or in the applications that carry out the device's purpose. In configuration communications, the host learns about the device and prepares it for exchanging data. Most of these communications take place when the host enumerates the device on power up or attachment. Application communications occur when the host exchanges data for use with applications. These are the communications that perform the functions the device is designed for. For example, for a keyboard, the application communications are the sending of keypress data to the host to tell an application to display a character.

Configuration Communications

During enumeration, the device's firmware responds to a series of standard requests from the host. The device must identify each request, return requested information, and take other actions specified by the requests.

On PCs, Windows performs the enumeration, so there's no user programming involved. However, to complete the enumeration, Windows must

have two files available: an INF file that identifies the filename and location of the device's driver, and the device driver itself. If the files are available and the firmware is in order, the enumeration process is invisible to users.

Depending on the device and how it will be used, the device driver may be one that's included with Windows or one provided by the product vendor. The INF file is a text file that you can usually adapt if needed from an example provided by the driver's provider. Chapter 11 has more details about device drivers and INF files.

Application Communications

After the host has exchanged enumeration information with the device and a device driver has been assigned and loaded, the application communications can be fairly straightforward. At the host, applications can use standard Windows API functions to read and write to the device. At the device, transferring data typically requires placing data to send in the USB controller's transmit buffer, reading received data from the receive buffer, and on completing a transfer, ensuring that the device is ready for the next transfer. Most devices also require additional firmware support for handling errors and other events.

Each data transfer on the bus uses one of four transfer types: control, interrupt, bulk, or isochronous. Each has a format and protocol suited for particular uses.

Managing Data on the Bus

USB's two signal lines carry data to and from all of the devices on the bus. The wires form a single transmission path that all of the devices must share. (As explained later in this chapter, a cable segment between a 1.x device and a 2.0 hub on a high-speed bus is an exception, but even here, all data shares the path between the hub and host.) Unlike RS-232, which has a TX line to carry data in one direction and an RX line for the other direction, USB's pair of wires carries a single differential signal, with the directions taking turns.

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.