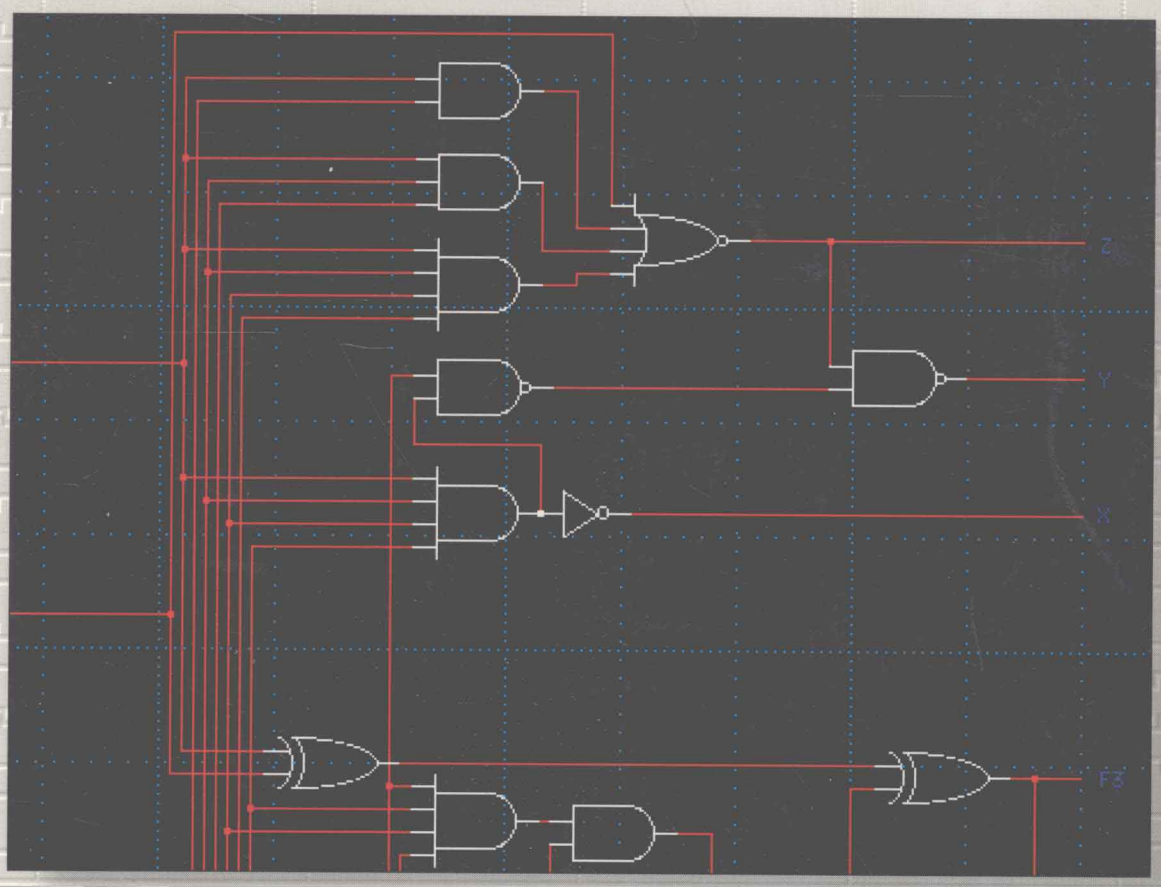
LogicWorks

INTERACTIVE CIRCUIT DESIGN SOFTWARE

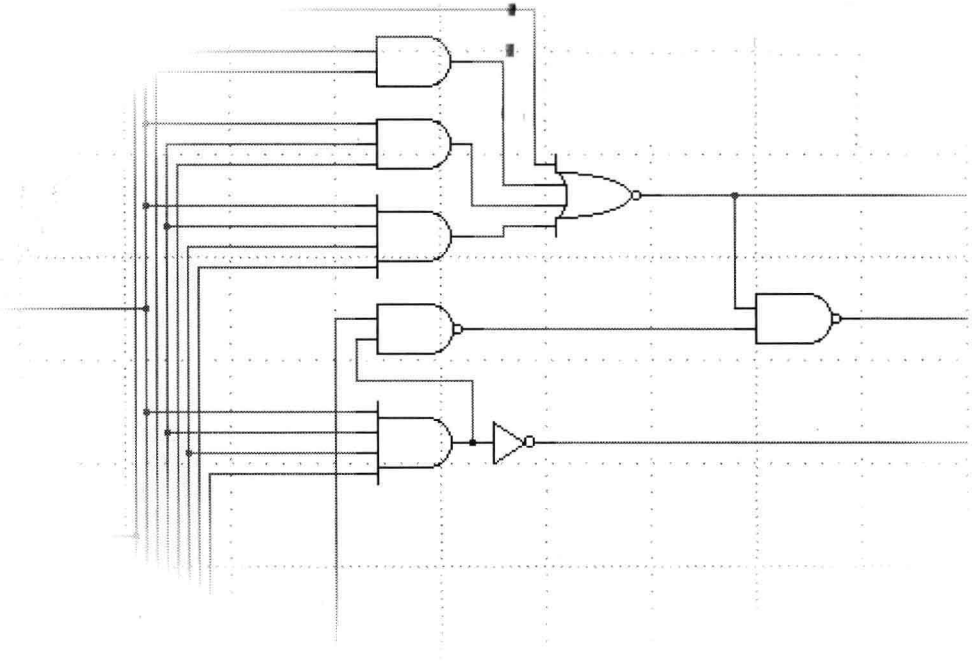


Macintosh® Version

CAPILANO COMPUTING SYSTEMS, LTD.

LogicWorks™

INTERACTIVE CIRCUIT DESIGN SOFTWARE



Capilano Computing Systems, Ltd.

The Benjamin/Cummings Publishing Company, Inc.

Redwood City, California • Menlo Park, California
Reading, Massachusetts • New York • Don Mills, Ontario
Wokingham, U.K. • Amsterdam • Bonn • Sydney
Singapore • Tokyo • Madrid • San Juan

Executive Editor: Dan Joraanstad
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Composition: Ideas to Images
Film: Just Your Type
Cover Printer: New England Book Components, Inc.
Text Printer and Binder: R. R. Donnelley & Sons
Senior Manufacturing Coordinator: Merry Free Osborn

Library of Congress Cataloging-in-Publication Data

LogicWorks [computer file] : circuit design tools. — [Version] 2.5 Macintosh.
2 computer disk : col. ; 3 1/2 in. + 1 manual.
System requirements: Macintosh SE or greater; 4MB RAM; System 6.03; monochrome or color monitor; hard disk; floppy disk drive; printer optional.
Title from disk label.
"The LogicWorks schematic and simulation system from Capilano Computing was designed by Chris Dewhurst and coded by Chris Dewhurst, David Taylor, and Ray Quon."—Title screen.
Student version of DesignWorks.
Audience: University and college students.
Issued also for the IBM-compatible PC.
Summary: An integrated schematic diagram and simulation program which allows students to design and test logic circuits. Upwardly compatible with Capilano Computing's DesignWorks professional circuit design system.
ISBN 0-8053-1312-5 (set). — ISBN 0-201-91505-7 (program disk). — ISBN 0-201-94245-3 (extras disk)
1. Logic circuits—Design and construction—Software. 2. Logic design—Software. 3. Computer-aided design—Software. I. Capilano Computing, Limited. II. DesignWorks.
TK7868.L6 <MRCRR>
621.39—dc12 93-5852
CIP

2 3 4 5 6 7 8 9 10 — DO — 97 96 95 94

The Benjamin/Cummings Publishing Company, Inc.
390 Bridge Parkway
Redwood City, California 94065

Preface

Welcome to the exciting world of interactive circuit design. As electronic systems have become more complex, operating speeds higher, and custom chip technology more widespread, software tools for engineers have become an essential part of the design process. It is no longer possible for an individual engineer or a corporation to remain competitive using pencil and paper for design. Powerful computer-aided design (CAD) programs have been commercially developed to meet the increasing demands facing industry. At Capilano Computing Systems, Ltd., our leading product, DesignWorks, is used in government, industrial, and academic labs worldwide, providing users with speed, ease of use, and affordability.

Many instructors want to give their students hands-on experience with CAD tools used in industry, but the high cost and complexity of most commercial CAD programs limit their use at academic institutions. In light of this, we developed LogicWorks, the student version of DesignWorks, to be used by students in lab settings and by instructors as an interactive teaching aid. We are proud to announce that a recent survey identified LogicWorks as the single most popular tool for teaching digital logic at universities.

Objectives

LogicWorks was developed with the following goals in mind:

- To give students an introduction to the concepts and practicalities of using CAD tools.
- To provide a "virtual workbench" that allows students to quickly test circuit design ideas and document results.
- To be easy and intuitive to use, so time is not wasted on the details of installing and operating the software.
- To offer the features and interfaces necessary to work with current technologies.
- To provide an upward path to professional design tools used in the industry.

Features

LogicWorks offers students and instructors the ability to:

- Quickly draw general-purpose schematic diagrams, using standard digital and discrete component symbols.
- Create schematics for SPICE-based analog simulators.
- Create custom symbol libraries with the built-in drawing tools.
- Generate simple netlists and bills of materials from the schematic.
- Interactively simulate the digital portions of the circuit, just as if it were built on a real breadboard.

These features, plus full upward compatibility with DesignWorks, makes LogicWorks an open-ended tool that can form the core of an electronics teaching and research environment.

Supplements

LogicWorks Laboratory Manual Free to adopters of LogicWorks, this manual consists of 12 laboratory exercises and two final projects developed for coursework at the University of Washington and the University of California at Berkeley. To obtain a free copy, please contact your local sales representative and ask for ISBN 0-8053-1313-3.

Acknowledgments

Many people at Capilano Computing and at Benjamin/Cummings Publishing provided invaluable help in bringing this version of LogicWorks to the world. Particular thanks go out to our editor, Jennifer Young, and her assistant, Laura Cheu, at Benjamin/Cummings and to Addam Smith and David Taylor at Capilano, all of whom remained cheerful and fun to work with despite setbacks and schedule pressures.

Other key contributors include our previous editor, Lisa Moller; our marketing manager, Mary Tudor; Neil MacKenzie and Angela Der at Capilano; and Gary Palmatier at Ideas to Images.

Special thanks go out to Gaetano Borriello and Carl Ebeling at the University of Washington and to Randy Katz, author of *Contemporary Logic Design* (Benjamin/Cummings), for their contributions to the laboratory manual and to Don Joy at Sonoma State University for reviewing these labs. We would also like to acknowledge our many friends and supporters in the academic and industrial worlds who continue to provide valuable feedback and support for the ongoing development of this product.

Chris Dewhurst
Vancouver, B.C., Canada
June 1993

Contents

1 Introduction

LogicWorks Features

Welcome to the world of electronics design on the Macintosh. The purpose of this manual is to get you acquainted as quickly as possible with all the powerful editing and simulation features of LogicWorks.

LogicWorks provides full schematic editing features integrated with an interactive digital simulator.

General Features

LogicWorks is compatible with all current Macintosh models with 2 or more megabytes of memory, including the Macintosh Classic,™ SE,™ and all Mac II–series machines, as well those of the Quadra and Centris series.

Fully interactive operation. Any circuit, input, or device parameter change immediately affects displayed circuit activity. The timing diagram is updated and scrolls continuously as the simulation progresses.

LogicWorks is upward compatible to the full DesignWorks™ professional circuit design system. All files created in LogicWorks can be read by DesignWorks.

Schematic Drawing Features

The DevEditor module (included with LogicWorks) allows any circuit to be assigned to a symbol, which can be created using the built-in drawing tools or imported from any external drawing program. Libraries of user-defined symbols are accessible from LogicWorks.

A circuit schematic can be up to a total of 5 feet by 5 feet. Any number of circuit windows can be open simultaneously, allowing easy copying of partial or complete diagrams from one file to another. Each circuit is displayed in a separate window with independent control of scroll and zoom.

Commands and drawing modes can be selected using menu items, keyboard equivalents, or a tool palette which is always visible in each window.

Any group of objects on the drawing can be repositioned with a simple click-and-drag mouse action. Signal lines are rerouted interactively to maintain right-angle connections.

Multiple signal-line routing methods allow most pin-to-pin connections to be made with only two mouse clicks.

Signal names are global across a schematic. Like-named signal traces on a page are thus logically connected for simulation and netlisting purposes.

Arbitrary text created in other programs can be pasted onto a circuit schematic. Similarly, complete or partial circuit diagrams can be pasted into word processing or drafting documents.

Arbitrary user-defined text attributes can be attached to any device or signal in a circuit. This information can be used to generate SPICE-type netlists.

Objects can be drawn in user-selectable colors on machines equipped with a color display.

Circuit and timing diagrams can be printed on the ImageWriter™ or LaserWriter,™ or written as MacPaint™ or PICT (MacDraw™) files for incorporation into other documentation.

Simulation Features

Full digital simulation capability. Circuit output may be displayed in the form of timing diagrams or on simulated output devices. Uses 13 signal states, including forcing and resistive drive levels to correctly simulate circuits with design errors such as unconnected inputs or conflicting outputs.

Device delay time for individual primitive components may be set to any integer from 0 to 32,767.

The timing display has adjustable time per division and reference-line placement.

Complex input sequences may be drawn directly on the timing diagram using the integrated waveform editor. Numerous timing editing features are available, including:

- Easy drawing and repositioning of signal edges
- Entry of Don't Know, HighZ, and Conflict states
- Cut/Copy/Paste/Duplicate of any grouping of signal traces
- Timing data is stored on the clipboard as text which can be copied to or imported from other programs
- An absolute time scale shows across the top of the timing diagram
- Delta-T measurements can be made by simply clicking the mouse

Common SSI and some MSI devices are implemented as primitives with hard-coded simulation functions. These can be used to create higher-level device functions.

Test and control devices such as switches and displays are active right on the schematic diagram, allowing circuit operation to be directly controlled and observed.

A Clock Generator device produces signals with variable period and duty cycle. Any number of clock generators can exist in one circuit.

Programmable Logic Arrays can be created with up to 96 inputs and 128 outputs with user-specified binary logic. When used with MacABEL,™ PLA logic can be specified using Boolean equations and state-transition logic. Programmable Read Only Memories with up to 12 inputs and 128 outputs can also be simulated.

Save State/Restore State commands allow the user to reset the simulation to any saved state to retry after a circuit change. The simulation can be single-stepped or walked (2 time steps per second) using the tool palette.

RAM devices of any configuration from 1 × 1 to 1 mB × 64 can be created and simulated (based on available memory). Device options include 0 or 1 OE inputs, 0 to 3 CE inputs, separate or combined data I/O pins, and three-state or normal outputs.

A "strip chart" printing mode allows continuous timing charts to be printed as the simulation progresses.

Interface Features

The Save Report command will generate the following types of text reports:

- Simple netlist format, listing all the device pins attached to each signal line
- Component listing, giving the name and type of each component
- Materials listing, showing all component types used and quantities
- Berkeley SPICE-type netlist, using node numbers
- Commercial SPICE format, using alphanumeric signal names

The powerful MEDA™ module interface allows specialized functions to be added to LogicWorks without modification of the program itself.

Limitations in This Version

The absolute maximum number of devices (including hidden devices in macros) is 32,767.

The typical number of devices without severe performance degradation is 500–1,000 on a Macintosh Classic or SE, 2,000–3,000 on a Macintosh II.

The maximum length of a pin number is four characters.

The maximum number of characters in an attribute block is 32,000.

The maximum number of pins on a device is 1,000.

The entire circuit must fit into available memory.