

Printed Circuits Handbook

50th
Anniversary
Edition!

SEVENTH EDITION

- Printed Circuit Supply Chain Management
- Lead-Free Materials and Processes
- Printed Circuit Reliability
- Printed Circuit Design and Layout Processes

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Clyde F. Coombs, Jr., and Happy T. Holden

PRINTED CIRCUITS HANDBOOK

Clyde F. Coombs, Jr. Co-Editor-in-Chief

Happy T. Holden Co-Editor-in-Chief

Seventh Edition



New York Chicago San Francisco Athens London
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Printed Circuits Handbook, Seventh Edition

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1 2 3 4 5 6 QVS/QVS 20 19 18 17 16

ISBN 978-0-07-183395-0

MHID 0-07-183395-1

This book is printed on acid-free paper.

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PRINTED CIRCUITS HANDBOOK

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PREFACE

This book provides the reader with the tools to be successful in the printed circuit world of today, and of the foreseeable future. A world where, increasingly, the designer/user organizations are not only different from the manufacturing organizations, they are separated by geography and language, and, perhaps most importantly, one where there is great opportunity for serious disconnect between the understanding of what is required by the user and what can be accomplished by the manufacturer. The term “supply chain” has been used to define these issues in general for non-vertically integrated organizations, but here, for the first time, we have focused specifically on those supply chain elements that relate to printed circuits. This includes design, specification, supplier identification and qualification, and process understanding and control, as well as quality and reliability specification and assurance. When a user organization entrusts its present, as well as its future, success to an outside manufacturing organization, the need for care and clarity cannot be overstated. Chapters, written by authors with experience in these issues, have been specifically developed to provide the reader with usable information on dealing with them, and will help guide the development of these relationships, for the benefit of all.

In addition, with the continued, and increasing, importance of printed circuits as the basic building block of all electronic devices, issues associated with them can be found throughout the engineering and manufacturing organizations, rather than in just design and layout in engineering and purchasing and product assembly in manufacturing. Knowledge of printed circuits, at some level, is needed by many staff members who find they have a need to understand the issues of a technology and industry that did not previously concern them. This book provides a reference, for those who are not printed circuit professionals, to find information on, and answers to, questions on process issues. It also helps define the appropriate questions to pose to either members of their own organization or the potential supplier, while developing the entire range of relationships.

From its beginning, the printed circuit has not only been one of the most important technology developments ever made, but one of the least understood and appreciated. It has often been mistakenly considered a “commodity” and purchased on the basis of board, or assembly, initial cost. In fact, there is no such thing as a “standard” or “generic” printed circuit. Every board is actually an “application-specific interconnection system” that can have immense impact on the performance, quality, reliability, and cost of the final product in which it is used. A problem that could have been resolved in the early design and acquisition processes may not be evident until the product is in use, when it is the most difficult and expensive to resolve. This book helps the reader deal with these issues at each step of the supply chain, which includes those inside the user organization as well as the supplier organizations. Specifically, these have brought about a new part entirely devoted to the understanding of, and working with, the printed circuit supply chain itself. The generic issues of supply chain management have been well documented; however, applying them to the specific problems created by printed circuits requires specialized understanding and is addressed only in this book.

While introducing new tools to address the supply chain issues, the book remains committed to its historical role of providing detailed descriptions of the technology and processes of printed circuits that have evolved over the years, and brought up to date in this edition. It remains the only single reference on all aspects of printed circuit technology. At the same time, when revising process chapters, we have included, where possible, a discussion of issues that the reader should consider when dealing with suppliers that are involved in making boards using these processes by addressing such questions as: What are the things that help the reader know if a supplier, in fact, has the capabilities to provide what is needed? What is unreasonable to expect? How can the desired result be demonstrated initially, and maintained over time?

In using contract manufacturing to fabricate and assemble boards, the user gives up the ability to define the design rules. Success will come by having a partnership with the supplier that reconciles the needs of the user with the capabilities of the manufacturing organization. To make the communications on printed circuit issues between the designer/user and the manufacturer clearer and more efficient, the book also contains new chapters,

and expanded revisions of existing chapters on design and layout of boards and assemblies. These include additional information on design and layout basics, high-performance boards, CAD tools, design for manufacturing, and information exchange systems and standards.

As electronic products have become more complex, with higher levels of performance expected, volumes never seen before, and new process and material challenges, such as “lead-free” soldering, the using organization has had to delegate more responsibility for much of the quality and reliability of the product to the supplier organization. In response, this book also contains critical new material on the reliability of boards and assemblies, with consideration for new base materials, and assembly processes. These chapters were developed specifically for this book, and much of their contents is not available anywhere else, and will allow the user to reach reasonable agreements on process controls and acceptance criteria that ensure the needs are met.

With the continuing concern over the impact on the global environment of printed circuit wet and fabrication processes, as well as assembled boards at the end of their useful life, the issue of RoHS (Restriction of Hazardous Substances), and specifically “lead free” has caused a revolution in the industry unprecedented in its history. Specific information on the impact of the resulting changes in materials and processes is documented and described. For example, for lead-free solders, we start with the Periodic Table and define what is even possible for an alternate alloy. Thus physics and material science are used to describe alternatives available.

The end result of these additions is essentially the creation of a new book, not just a new edition. Twenty-five percent of the chapters are new to this edition, while only 16 percent are reprinted from previous editions.

The publication of this book coincides with the 50th anniversary of the publication of the first edition. That book had 16 chapters, contributed by 11 authors. This edition, the seventh, has 71 chapters contributed by 38 authors. This clearly reflects the development of the level of the technology, as well as the expansion of the user base for printed circuits over time. The fact that this book has maintained a high position of usefulness and importance to those in the printed circuit field for this length of time must really be attributed to the skills of the authors who have contributed chapters developed from their considerable knowledge and expertise in their respective areas and at considerable time expense. It has been said that the author list for this book reads like a “who’s who” in the printed circuit industry. This has resulted in information the reader can actually use to solve problems.

We also thank the IPC—Association Connecting Electronics Industries, which has given this book total cooperation and support for every edition. We would especially like to acknowledge the active help and encouragement of IPC managers Anne Marie Mulvihill, David Bergman, and Greg Munie (who also authored a chapter). Their efforts were a great contribution to our ability to accomplish the development of a project of this size and complexity.

*Clyde F. Coombs, Jr.
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