

Boundary-Scan Test

A Practical Approach

by

Harry Bleeker

Peter van den Eijnden

*Fluke/Philips Test & Measurement,
Eindhoven, The Netherlands*

and

Frans de Jong

*Philips Research Laboratories,
Eindhoven, The Netherlands*



KLUWER ACADEMIC PUBLISHERS

DORDRECHT / BOSTON / LONDON

Published by Kluwer Academic Publishers,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

Kluwer Academic Publishers incorporates
the publishing programmes of
D. Reidel, Martinus Nijhoff, Dr W. Junk and MTP Press.

Sold and distributed in the U.S.A. and Canada
by Kluwer Academic Publishers,
101 Philip Drive, Norwell, MA 02061, U.S.A.

In all other countries, sold and distributed
by Kluwer Academic Publishers Group,
P.O. Box 322, 3300 AH Dordrecht, The Netherlands.

Printed on acid-free paper

All Rights Reserved

© 1993 Kluwer Academic Publishers and copyright holders
as specified on appropriate pages within.

No part of the material protected by this copyright notice may be reproduced or
utilized in any form or by any means, electronic or mechanical,
including photocopying, recording or by any information storage and
retrieval system, without written permission from the copyright owner.

Printed in the Netherlands

LIST OF FIGURES

PREFACE

PCB TESTING

MINIATURIZATION
ROAD BLOCKS
THE SOLUTION
Test Control
Example Board
Constituent Elements

THE BOUNDARY-S

THE BEST ARCHITECTURE
TEST ACCESS POINTS
TAP CONTROL
State Description
THE INSTRUCTION SET
TEST DATA RECORDING
The Bypass Register
The Boundary-Switch
A Boundary-Switch
System Pin Register

has lead to a world
IC designs allows
epare *standard* test.
duct.

er 1 states the PCB
the standard for the
the innovations for
opments in BST are
have been obtained
5 describes various
tion faults are met,
ed. Chapter 6 gives
roducing BST in a
g aspects. The book
quick reference.

standing of ICs and

a technological level
ussions and positive
ould be mentioned
and his conscientious
to Rien van Erk for
probably not have

MINIATURIZATION IN ELECTRONICS

Printed Circuit Boards (PCBs) add the most value to electronics hardware. Over the years, PCBs have become loaded with more components and hence have become increasingly complex and expensive. This is mainly caused by the ongoing miniaturization in electronics.

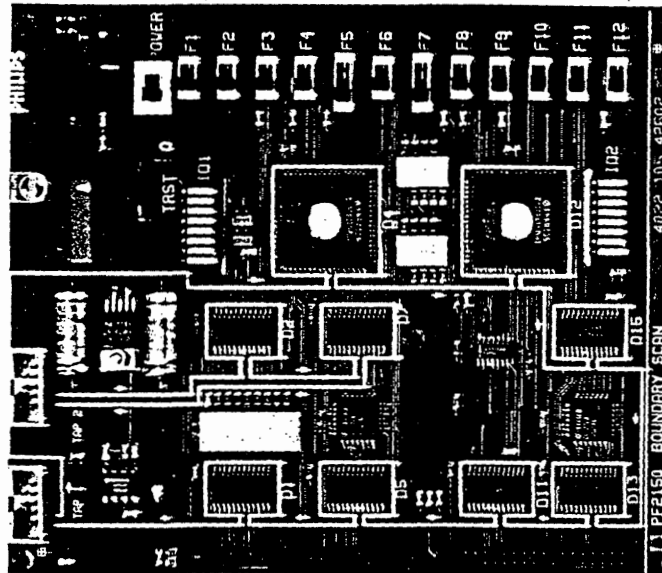


Fig. 1-1 A printed circuit board containing ASICs

To start with, the miniaturization within integrated circuits (ICs) themselves has progressed into the sub-micron technology. This has led to an increased number of gates and a very large number of functions per chip. Consequently, many more pins per IC are needed and hence ICs come in bigger packages with more leads (>500 pins) at smaller pitches (0.3 mm). Therefore, the distance between the foot prints of the ICs on the PCB is becoming equally small.

other technologies are becoming available: Multi Chip Modules (MCMs). These are functional modules built up of dies directly mounted on top of several dielectric and metallization layers supported by a ceramic multi-layer substrate. The component density is very high and accessibility other than via the input and output pins of the MCM is non-existent.

Figure 1-2 shows the reduction of trace distances on PCBs and in ICs.

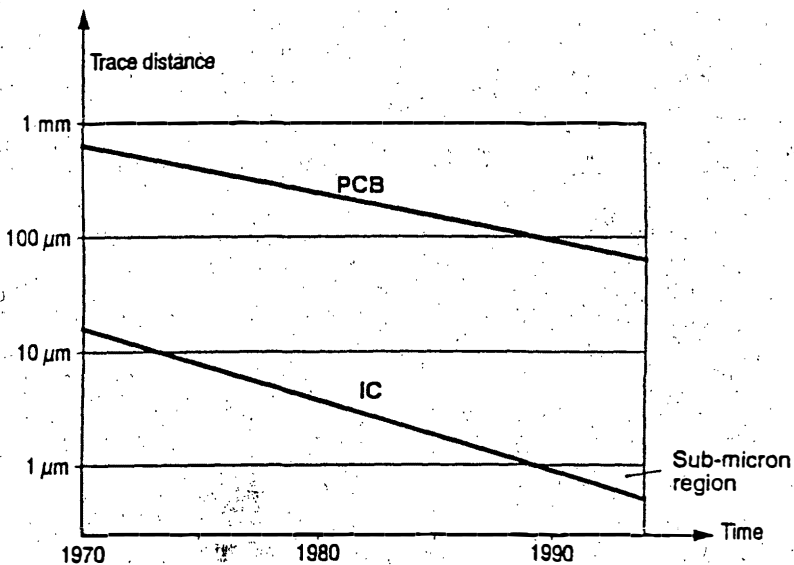


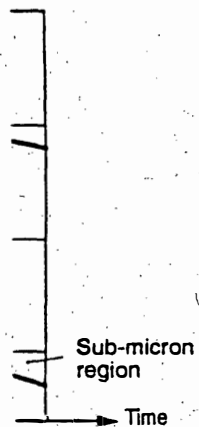
Fig. 1-2 Reduction of trace distances on PCBs and in ICs

Figures 1-3 and 1-4 show, respectively, a part of a PCB and a part of an IC which is soldered onto that PCB. These pictures are taken with a Scanning Electron Microscope and the pitch of the IC's contact pins is 25 mil ($= 1/40$ inch ≈ 0.63 mm).

The ongoing miniaturization has made it more and more difficult to access these "highly loaded" PCBs mechanically, with fixtures, for in-circuit testing. Moreover, the test equipment became so expensive in the 1980s that it severely affects the profitability of producing PCBs. Electronic companies were, therefore, looking for low-cost test methods based on the sofar hardly explored design for testability.

s per unit of surface,
s (MCMs). These are
several dielectric and
trate. The component
nd output pins of the

nd in ICs.



part of an IC which
Scanning Electron
 $1/40$ inch = 0.63 mm).

icult to access these
it testing. Moreover,
severely affects the
herefore, looking for
ign for testability.

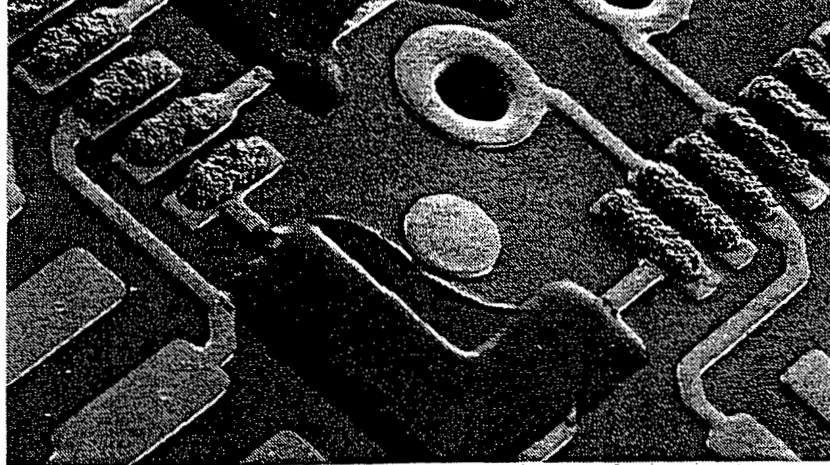


Fig. 1-3 Electron microscope picture of part of a PCB

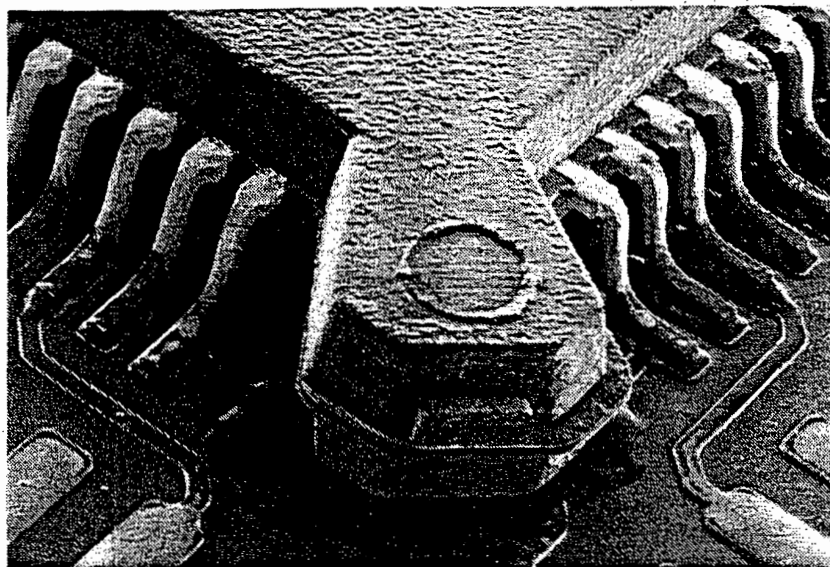


Fig. 1-4 Electron microscope picture of a soldered IC on a PCB.

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.