

The story of the I²C Bus

START AND STOP CONDITIONS

The diagram shows the SDA (Serial Data) and SCL (Serial Clock) lines. The SCL line has a high level during transmission and a low level during reception. The SDA line has a high level during reception and a low level during transmission. The start condition (S) is indicated by a dashed box around the first falling edge of SCL. The stop condition (P) is indicated by a dashed box around the last falling edge of SCL.

PHILIPS SERIAL BUSES.

The diagram shows a multi-master bus topology. A horizontal bus line is connected to four devices: HI-FI, D2B, TV, D2B, and VCR. Each device has a BUS INTERFACE block connected to the bus line. The TV device has a PC BUS CLOCK block connected to the BUS INTERFACE. The TV device also has a TUNING block, a CONTROL block, a MEDIA CONTROL block, a TIMER block, a DATA block, and a DSB/PRAC block. The HI-FI device has a TUNER block and a TONE CONTROL block. The VCR device has a DISPLAY block.

THE I²C BUS

Ad Moelands

Two Wires: The story of the I²C Bus

All rights reserved. Reproduction in whole or in part is prohibited without the prior written consent of the copyright owner.

The information presented in this document does not form part of any quotation or contract, is believed to be accurate and reliable and may be changed without notice.

No liability will be accepted by the publisher for any consequence of its use.

Publication thereof does not convey nor imply any license under patent- or other industrial or intellectual property rights.

Date of release: September 2026

I²C is a registered trademark of NXP B.V.

**NXP has not been involved in nor authorized the content of this
book**

Preview version

Two Wires

The story of the I²C Bus

Ad Moelands
Co-inventor of the I²C bus

For
Herman Schutte
15 June 1941 – 19 September 2021

*Respected colleague, co-inventor, and indispensable
to everything described in these pages.*

The I²C bus would not exist without him.



Source: Mrs. Schutte

Table of Contents

1	Preface	1
2	Introduction	5
3	Finding the past	9
4	My background	13
5	Before the I ² C bus was created	23
6	The first steps	31
7	Resistance, competition and adoption	51
8	From concept to silicon	65
9	Adoption and promotion	73
10	Reflection and closing thoughts	81
	Appendix I	86
	Appendix II	114

Two Wires: The Story of the I²C Bus

CHAPTER 1

Preface

"Make things as simple as possible, but not simpler."

— Albert Einstein

This book should have been written by two people.

My intention, when I first found some old documents in a box in my attic, was to contact Herman Schutte — my former colleague and co-inventor of the I²C bus — and propose that we write this account together. It seemed only right. The bus had been our shared creation, shaped by months of technical discussions and complementary approaches to engineering problems. I felt that the story of how it came to be was not mine to tell alone. The I²C bus was not my invention. It was ours. Herman and I approached problems from different angles, emphasized different aspects, and it was precisely that combination that produced the result.

Two Wires: The Story of the I²C Bus

In trying to contact him, I learned that Herman had passed away on 19 September 2021. We had not been in regular contact in the years since my career at Philips had ended — the distance between former colleagues grows naturally over time. Finding out that he was no longer among us before I could make that call was one of the genuine regrets of this project.

It meant that writing down the story of how the I²C bus was conceived would depend entirely on the documents I found in the attic and on what I could still remember of events more than forty-five years ago. Fortunately, two of those documents were exceptional. They contained the transcripts of sworn depositions that Herman and I had given in 2002 in Amsterdam, in a patent dispute brought by Philips against several IC manufacturers. Those transcripts record how we both remembered, twenty years later, the period when we developed the bus. Herman's testimony in particular — several days of transcript, in his own words and his own voice — is, in a very real sense, his contribution to this book.

I also wish to mention two former colleagues who made real contributions to the technical development and implementation of the bus and whose names should be on record.

Sjaak Bakker, who at the time worked as an engineer in our laboratory, played an important role in making the MAB8400 microcontroller practically usable for application engineers.

I was in contact with him while writing this book, and his contribution is reflected in these pages.

And I would also like to acknowledge Dr. Volker Timm, who led the team that implemented the MAB8400 microcontroller, and with it the first I²C interface, in silicon at the Valvo factory in Hamburg.

Preface

Everything described here is how I remember it, corroborated where possible by the 2002 depositions and original documents from that period. I have not attempted to reconstruct the exact organizational structure of Philips Elcoma in the late 1970s and early 1980s with legal precision. If names or contributions are missing, that is a limitation of memory and available records, not an intentional omission.

A note on names: the colleagues named in this book are mentioned in their professional capacity, in a factual and positive context, as participants in a shared piece of engineering history. Where I have been in contact with them, they are aware. Where I have not, whether because time and distance made it difficult, or because they are no longer with us, I have tried to represent their contributions accurately and with respect. Any errors of recollection are entirely my own.

Ad Moelands

Two Wires: The Story of the I²C Bus

CHAPTER 2

Introduction

October 2002. A conference room in Amsterdam.

A video recorder running. On one side of the room, lawyers for several IC manufacturers. On the other, lawyers for Philips and, as witnesses, Herman Schutte and myself. The subject of the proceedings was a patent dispute. Yet the answers we gave over the following days were about something else: how two engineers, working in the central application laboratory of Philips in Eindhoven in the late 1970s, had developed a two-wire communication system that would still be in active use more than forty-five years later.

The depositions were taken two weeks apart — Herman on 22 October, me on 7 November. Each session lasted several days. What I did not know at the time was that those transcripts would eventually become the primary source for a book about the I²C bus.

Two Wires: The Story of the I²C Bus

I found them by accident in a box in my attic, and it was only after some time that the idea arose to use them for a book on how the I²C bus was born.

The I²C bus is, by any measure, one of the most successful communication protocols in the history of consumer electronics. Even more than forty-five years after its introduction, the bus continues to appear in new hardware — from the Raspberry Pi and the ESP32 family to countless industrial microcontrollers and peripherals. It became a de facto standard across the semiconductor industry, though it never set out to be one. Yet the story of how it came to exist has never been written up in any accessible form. The technical documentation is abundant. The history is not.

This book aims to fill that gap. It is not a textbook on the I²C bus; technical resources exist elsewhere in abundance. It is a first-hand account of how the bus came into existence: the problems that drove its development, the key decisions and the people who made them, the internal resistance that had to be overcome, and the path from a whiteboard in Eindhoven to a protocol embedded in billions of devices. It draws on my own memory, on Herman's deposition testimony and my own, and on original documents that survived the decades.

This is also, necessarily, a partial account. It reflects how I remember things, supplemented by Herman's words and by contemporary documents.

It does not attempt to be a complete institutional history of Philips Elcoma. Some names are missing not from any desire to omit them, but because forty-five years is a long time and memory is imperfect.

Introduction

Finally, this is a book about professional collaboration. The I²C bus was not the work of one person. It emerged from the particular combination of two engineers who worked closely together, discussed problems without reservation, and neither of whom tried to impose conclusions on the other. That working relationship was the basis for the invention. The management support we received and the contribution of the people who helped with the implementation of the bus concept should also not be underestimated. I want it to be clear from the first page to the last.

A reconstruction of what Herman and I said in 2002 — our testimonies woven together around the sequence of events, in our own voices — can be found in Appendix I at the end of this book.

LIPS CORPORATION,
Plaintiff,
v.
DN/LBI
Defenda

United States Patent [19] Moelands et al.

[54] TWO-WIRE BUS-SYSTEM COMPRISING A
CLOCK WIRE AND A DATA WIRE FOR
INTERCONNECTING A NUMBER OF
STATIONS

[73] Inventor: Adriaan P. M. Moelands,
Herman Schaine, both of Eindhoven,
Netherlands
[72] Assignee: U.S. Phillips Corporation, New York,
N.Y.

[21] Appl. No.: 317,683
[22] Filed: Nov. 2, 1981

[13] Ref. Cl.: G06F 13/42
[31] U.S. Cl.: 364/200; 364/300
[59] Field of Search: 364/200, 364/300; 378/14,
378/15, 311, 106; 360/375-29; 825-15; 370/16,
85, 98

References Cited
U.S. PATENT DOCUMENTS
3,697,589 1/1971 Farmer
3,812,258 1/1975 Grinstein et al.
3,860,266 3/1975 Rabinovitch
3,860,345 3/1977 Rogoff
3,720,760 3/1973 Watson et al.

[11] Patent Number: 4,689,740
[45] Date of Patent: Aug. 25, 1987

3,738,485 2/1974 King et al.
3,809,210 3/1974 Harper et al.
3,802,266 10/1973 Steinet
4,104,369 3/1979 Steinet
4,161,812 7/1979 Dattani et al.
Primary Examiner—Gareth D. Shaw
Assistant Examiner—Christina M. Reitzmann
Attorney, Agent, or Firm—Jack E. Haken

ABSTRACT

A computer system comprises a number of stations which are interconnected by means of a clock bus wire (20) and a data bus wire (22) which both form a wired logic structure or bus system. Data is transferred by the data bus wire of each station, to and from the clock bus wire. Data and clock signals are formed by a signal combination between clock bus wire and data bus wire (36 and 38, respectively) which is not master clocked so that a composite clock signal occurs on the clock bus wire. The clock signal occurs as a composite clock signal. The clock signal is formed by a signal combination between clock bus wire and data bus wire (36 and 38, respectively) which is not master clocked so that a composite clock signal occurs on the clock bus wire. The clock signal occurs as a composite clock signal.

35 Claims, 7 Drawing Figures

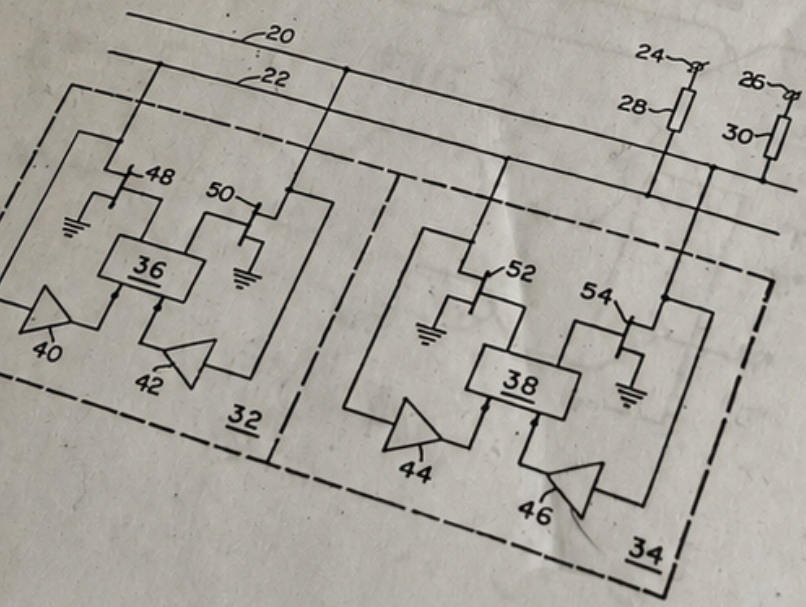


EXHIBIT
Moelands 1
CWA 10/7/82

CHAPTER 3

Finding the past

When you relocate to a new house, you open boxes that have not been touched for years, sometimes decades. Many things that you know you want to keep are often stored in boxes in a place where they don't get in the way, but which are therefore also easily forgotten.

→→→

HAPTER 5

Before the I²C bus was created

Before describing how the I²C bus was developed, it is useful first to describe the environment from which it emerged, not only the technical landscape, but also the organizational one, because in this case the organization mattered.

How Philips was structured

At the time, Philips was not organized in the centralized way common to many large companies today. It consisted of several main industry groups, among them Lighting, Video, Audio, Elcoma (Components), Medical Systems, and Telecommunications & Data Systems.

Within each group, development activities were spread across different countries and were often influenced by the requirements of local markets.

Two Wires: The Story of the I²C Bus

On the southern edge of Eindhoven, Philips maintained its Physics Research Laboratory, commonly known as the NatLab, which was primarily devoted to fundamental research.

For more application-oriented work, each main industry group had its own network of application laboratories. Elcoma had the Central Application Laboratory (CAB) in Eindhoven, the Valvo application laboratory in Hamburg-Stellingen, the Mullard laboratory in Mitcham near London, and a laboratory near Paris operating under the name RTC. Each had its own focus and expertise, and each operated with considerable autonomy.

This structure had genuine advantages. It encouraged local innovation and allowed rapid responses to regional market requirements. But it also had a consequence that became increasingly significant as digital techniques began to enter consumer electronics: the different laboratories had developed their own ways of doing things — including their own bus systems.

The different bus systems within Elcoma

The Mullard laboratory in the UK had developed a three-wire bus for the chipsets used in Teletext and Viewdata systems. I remembered it as being called MI-BUS.

One such Teletext service in the UK was Ceefax. However, it is possible that the bus was actually called I-BUS, since that is the name I encountered during my later research in the technical note on Multitext shown in an earlier image.

In any case, it was a three-wire bus.

Before the I²C bus was created

→→→

Two Wires: The Story of the I²C Bus

CHAPTER 6

The first steps

The first concrete attempt at a solution appeared in a document dated 24 April 1979.

It was the result of discussions I had with a colleague named Niels Malotaux, and it proposed a bus system as a candidate for replacing the existing incompatible bus systems.

The proposal was still based on a three-wire structure — no improvement over the existing three-wire systems. On closer examination, the system proved capable of exchanging handshake signals between devices, but not of reliably transmitting data. It was more a structured exploration of possible solutions than a workable design, and it was set aside. But the fact that work was already underway in April 1979 gives some indication of how seriously the interconnection problem was being taken at that point.

Two Wires: The Story of the I²C Bus



internal laboratory report

central application laboratory CAB
eindhoven - the netherlands

CONFIDENTIAL

number: TVE 79118	date: 24.04.1979
project: 6864	pages: 18 5
title: <u>PRELIMINARY PROPOSAL FOR A SUBSYSTEM INTERCONNECTION BUS</u>	
author: A.P.P.M. Noelands/N.R. Malotiaux	
summary:	In this report a proposal is given for a three wire interconnection bus. This paper is mainly intended as a guide for the discussions in the initial phase, and will be followed by a more detailed

used as such without the written consent of:
Leidingen/Leidingen - Eindhoven - The Netherlands
in Electronic Components and Materials

Source: Own archive

I mention this report here not for its technical significance, but because it is one of the first — perhaps even the very first — laboratory reports that clearly marks the point at which serious attempts were being made to solve the communication problem. In that sense, it also marks more or less the beginning of the development of the I²C bus. Not long after this document was written, Niels left Philips to start his own consultancy company, and consequently was not involved in the later development of the bus.

The first steps

The COBUS and the One-Wire question

While the internal discussions continued, I first made it my business to survey what bus systems were known or existing outside Elcoma. In the course of that survey I had discussions with colleagues at the Philips Research Laboratory, commonly known as the NatLab. From a conversation that I had there, a document emerged describing a Swiss one-wire bus system called the COBUS.



Appendix I

Editor's Note: This appendix presents selected answers given under oath by Ad Moelands and Herman Schutte during depositions in October 2002. The original lawyers' questions have been rewritten as neutral questions that preserve their core meaning and the context required to understand each answer. Conversational and lawyer-specific wording has been removed where possible. The selected answers themselves have not been rewritten and are reproduced as transcribed. Apparent transcription errors, incomplete words, and other irregularities in the original record have therefore been retained rather than corrected. The material has been reorganized for readability but does not always follow an exact chronological order, as the two depositions cover overlapping subjects and sometimes return to events discussed earlier. Procedural exchanges, attorney names, exhibit-management discussions, questions relating solely to legal issues, repetitive passages, answers concerned only with detailed circuit implementation—such as where an individual flip-flop is used and comparable component-level details—and brief confirmations have been omitted to increase readability. Material considered potentially company-confidential or commercially sensitive has also been omitted. Names of companies and individuals associated solely with the legal proceedings, as well as other identifying information not relevant to the historical purpose of this appendix, have likewise been omitted.

Appendix I

Question: What was your position at Philips and what was your last position when you left?

(Ad): I finished my studies at the technical university in 1976 and started immediately at the Central Application Laboratory at Eindhoven for Elcoma at that time. Around 1980 I joined the commercial department as the strategic product marketing manager MOS controllers and in 1986 I became responsible for the product marketing of the sales group of the Philips components sales organization in the Netherlands. After two years, around 1988, I became the General Manager of the sales group of Philips Elcoma in the Netherlands.

Question: Did you have a position when you were at Elcoma in the application laboratory?

(Ad): Yes, I was appointed to be an application engineer.

Question: Were there particular applications you were assigned to?

(Ad): They varied over time a little bit. When I started at the application laboratory it was the beginning of Teletext and Viewdata. So I helped introducing these systems in the Dutch laboratory. Somewhat later I was asked to look for digital applications within television sets, which meant a more architectural job.

Question: Were you involved in the design or development of the MAB8400?

(Herman): I was involved in the design of the MAB8400.

Two Wires: The Story of the I²C Bus

Question: Were you also involved in the design of the 8500?

(Herman): I was also involved in the design of the 8500.

Question: Please describe your involvement in the design of the MAB8400?

(Herman): My involvement in the design of the MAB8400 was in designing the serial I/O of the MAB8400.

Question: Who else was involved?

(Herman): That was Mr. Moelands.

Question: Was there anyone else involved in that project?

(Herman): Further were involved the people of the design group of the MAB8400. That were people from Philips Hamburg, Mr. Timm and Mr. Lauenhardt.

Question: Were there anyone else involved other than Mr. Moelands, Mr. Timm and Mr. Lauenhardt in the design of the serial I/O of the MAB8400?

(Herman): No, they did not really contribute to the design, other people.

Question: When did you first become involved in the definition of what became I²C?

(Ad): That must be somewhere around 1976 or 1977, so really quite early. As I told you I started working with the Teletext blocks, they had already some digital content and quite soon after that we became discussing how to connect

Appendix I

different blocks within a television set to reduce the interconnection costs of all sorts of digital blocks. So I would say around 1977.

Question: When you say “we started discussing how to connect the blocks”, who else are you referring to?

(Ad): My colleagues of the application laboratory at that time. It was a quite broad discussion. It were not only the contacts in Eindhoven but also contacts with the different application laboratories abroad that Philips had at that time.

Question: Do you know how you came to be working on the serial I/O of the MAB8400?

(Herman): In the TV system we needed a serial bus which would be able to do a multi-master function.

Question: Why did you need a multi-master function?

(Herman): Because we thought that you would have in the future more microprocessors or microcontrollers in one system and they should be able to communicate with each other.

Question: Were you thinking particularly in the TV context?

(Herman): Well, in first instance it was TV because I was giving support to the Teletext system in the TV and in that time also digital tuning and remote control, which is also digital, were coming →→→

Continue the story

This preview has introduced the origins of the I²C bus and a first glimpse of the recollections recorded in the 2002 depositions.

The complete book continues with:

- the detailed development of the bus architecture
- the technical and organizational challenges
- resistance and adoption within Philips
- the implementation in silicon
- the international promotion of I²C
- the complete reconstructed depositions
- historical appendices and original documents

For more information and to order the complete edition:

www.i2cstory.com

Two wires changed the way electronic systems communicate

In the late nineteen seventies, engineers at Philips faced a practical problem: getting many integrated circuits to communicate with each other using as few wires as possible.

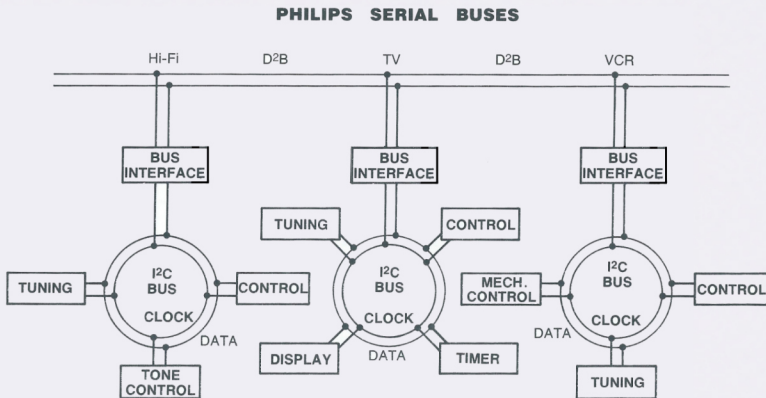
The solution became the I²C bus - a simple, elegant interface that would quietly become one of the most widely used standards in electronics.

This book tells the inside story of how the idea emerged, how it was developed, and how it proved its value in countless applications around the world.

This book is also a tribute to **Herman Schutte**, colleague, collaborator, and co-inventor of the I²C bus.

Our work was never the result of one perspective alone. The I²C bus emerged through discussion, experimentation, and complementary thinking.

Herman passed away in 2021, before we had the opportunity to tell this story together. This book is, in part, an attempt to bring that shared history back to life.



The I²C bus proved to be robust, flexible, and easy to implement. As a result, it found its way into televisions, audio systems, computers, phones, and countless other products we use every day.



Ad Moelands

Co-inventor of the I²C-bus

He worked at Philips during the transition from analog to digital consumer electronics. Following his contribution to the development of the I²C bus, he focused on promoting its worldwide adoption and acceptance.



Herman Schutte

Co-inventor of the I²C-bus

A brilliant engineer with a deep understanding of systems and interfaces, whose insights and creativity were essential to the invention and success of the I²C-bus. He also remained closely involved in the development of later versions.

