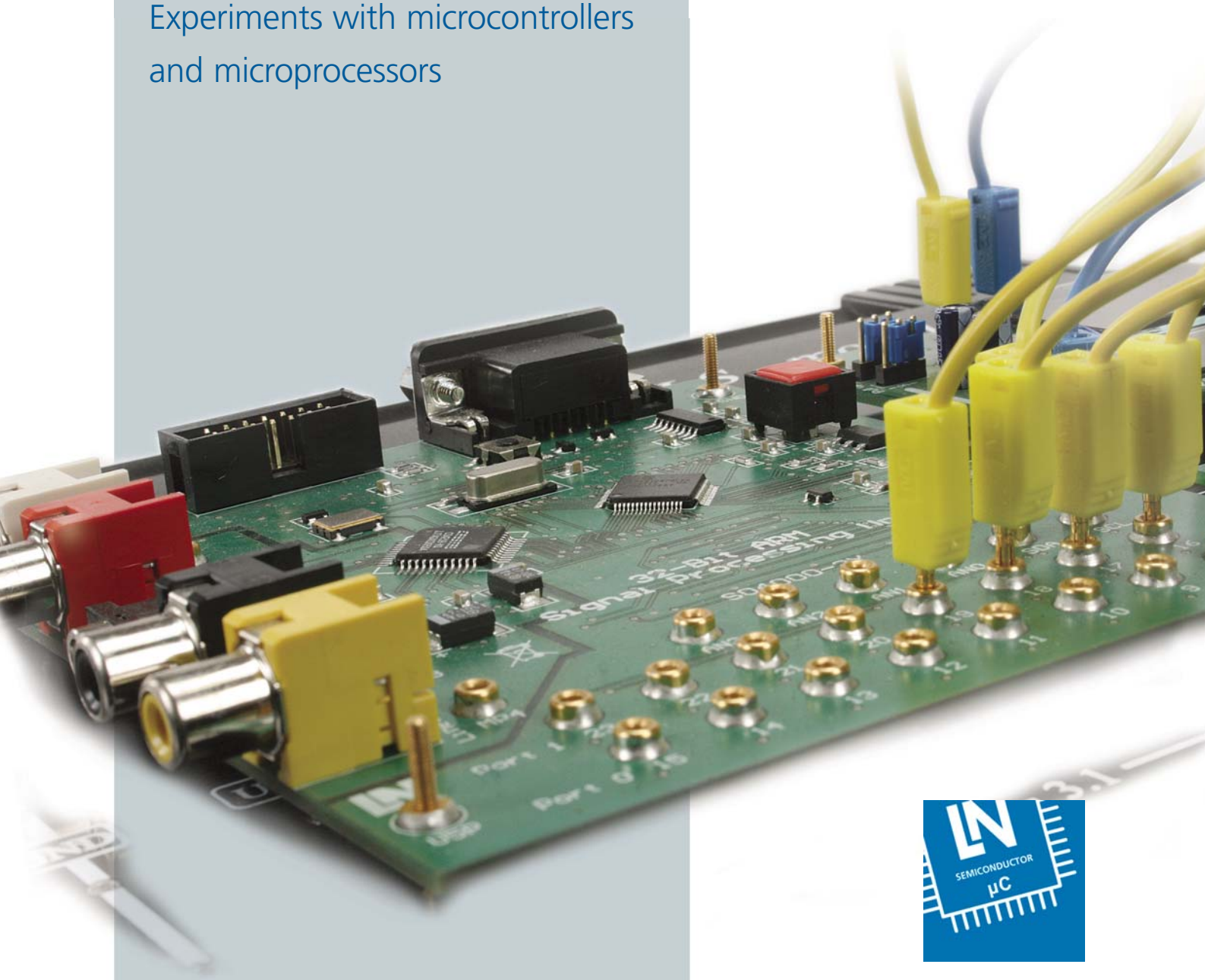
LUCAS-NÜLLE

MCLS-modular®

Microcomputer engineering

Experiments with microcontrollers
and microprocessors

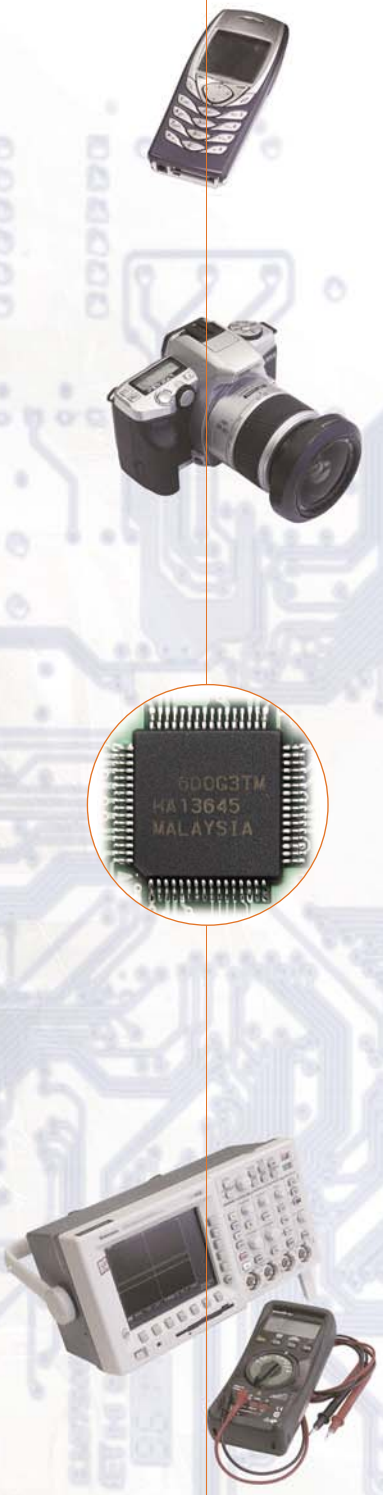


SEMICONDUCTOR
µC

They are everywhere.

Practically everything seems to need one.

They have become an indispensable part of our daily life.



Nowadays an entire microcomputer fits onto a chip no bigger than 2 mm x 2 mm.

Contents

Meeting growing requirements

MCLS-modular®

The MCLS-modular® microcomputer training system grows with your needs.

How things have changed

The market for embedded systems has boomed in recent years like never before, with companies in this sector urgently seeking specialised staff.

The training environment for microcomputer technology has also undergone major transformations:

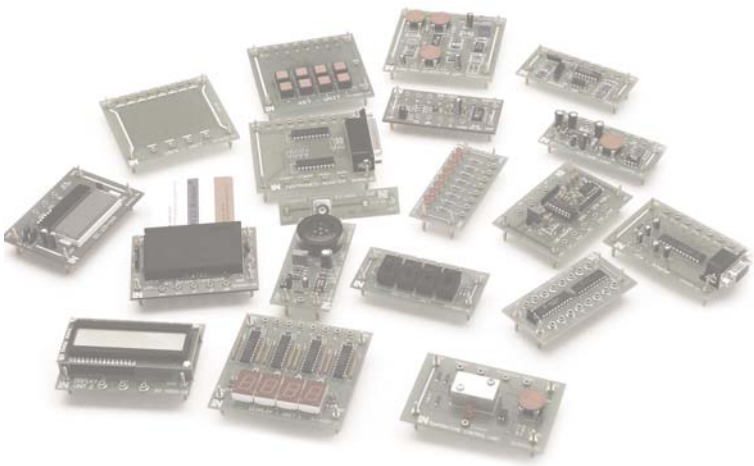
- High rate of innovation
- Shrinking budgets
- Rising demands

Comprehensive modularity

A scalable system of modular hardware and software allows you to upgrade components as technology advances without ever having to completely replace your system.

This notably reduces:

- Replacement costs
- Learning curves
- Staff retraining



Support

Rapid innovation in microcontroller and microprocessor technology entails regular modifications to the systems involved. Consequently, Internet support is an important part of the MCLS-modular® package.
System obsolescence is avoided by providing a steady supply of up to date information.

www.mcls-modular.com

Here you will find:

- Help functions
- System-related information
- Hardware descriptions
- Downloads

Simple and up to date

- Education through experiments, testing and practice
- High degree of motivation through successful learning with retention
- Clear set up and easy handling
- Low costs
- Always abreast of the latest technology

Comprehensive modularity

Always abreast of the latest technology

MCLS-modular® is a microcontroller experiment and training platform designed to keep pace with all the latest technical innovations.

Hardware

MCLS-modular® provides comprehensive flexibility and variety in terms of hardware components:

- Microcontrollers, microprocessors and digital signal processors from different manufacturers can be used (e.g. Infineon, Motorola, ATMEL, MICROCHIP, Texas Instruments)
- A large and extensible inventory of peripheral hardware (application modules) is available
- Experiments can be freely configured
- Microcontroller units are interchangeable
- Components can be exchanged or supplemented as required
- Peripheral hardware can be added as required

Basic components

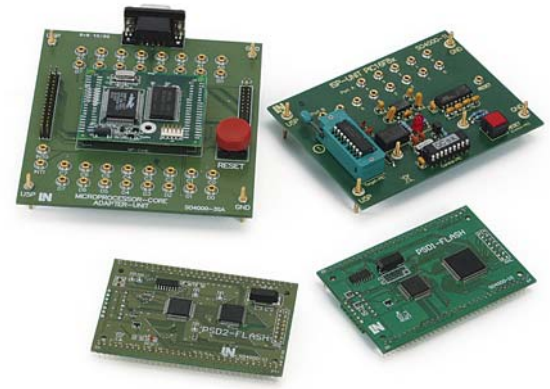
- Experiment platform
- Universal power supply with current protection
- Serial connection cable
- Set of patching leads

Suitable for processors from:
Infineon, Motorola, ATMEL, MICROCHIP and Texas Instruments

Microcomputer modules

Designed for training in fundamentals:

- 8051 controller with 256 kB on-board flash memory for programming in assembler and C (C515C)
- PIC16F8x controller board for programming, flash updates and testing the established PIC16F84
- Modern 8-bit controller with Motorola-compatible instruction set (68HC11)
- Modern 16-bit microprocessor with Z80-compatible instruction set for assembler and C (256 kB flash memory, 128 kB RAM) and others



32-bit controller board

- Latest technology based on 32-bit advanced RISC machines
- C programming
- JTAG programming interface
- High-end applications including digital signal processing
- CODECS included

Experiment modules

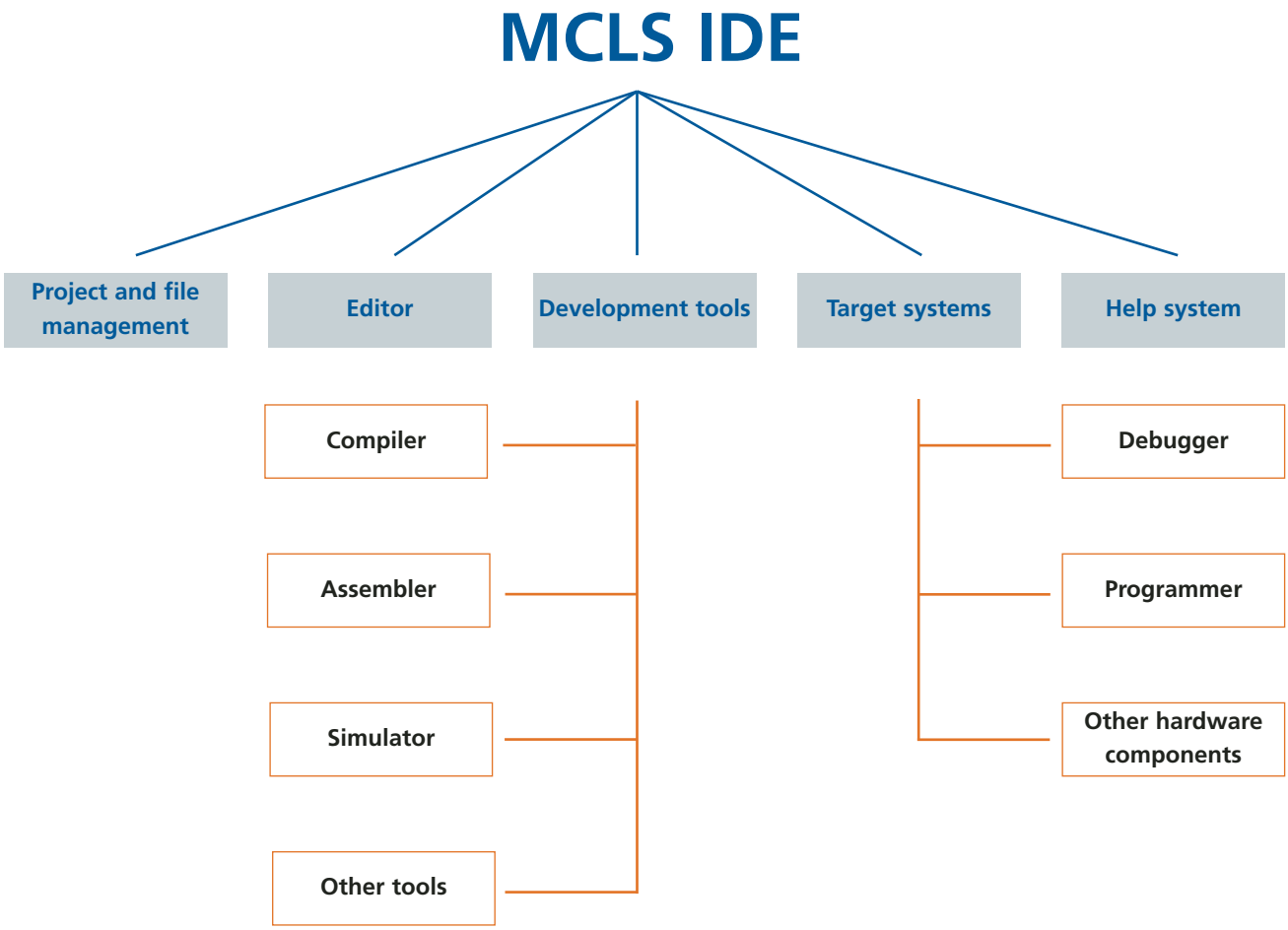
- Basic modules such as switches, buttons and LEDs
- Display modules like 7-segment and LCD displays
- Converters and sensors including A/D, D/A and temperature converters
- I^2C addressable modules including LCD display and smart card
- Serial and parallel interface modules
- Application modules, e.g. traffic-light controller
- Stepper motor control

Comprehensive modularity

Integrated Development Environment (IDE)

The IDE for Windows NT, 2000 and XP fulfills the following essential functions for the system as a whole:

- Integration of all necessary software development tools
- Project management for a variety of target systems
- Use of modern UI concepts in Windows NT, 2000 and XP
- Provision of interfaces for flexible incorporation of development tools



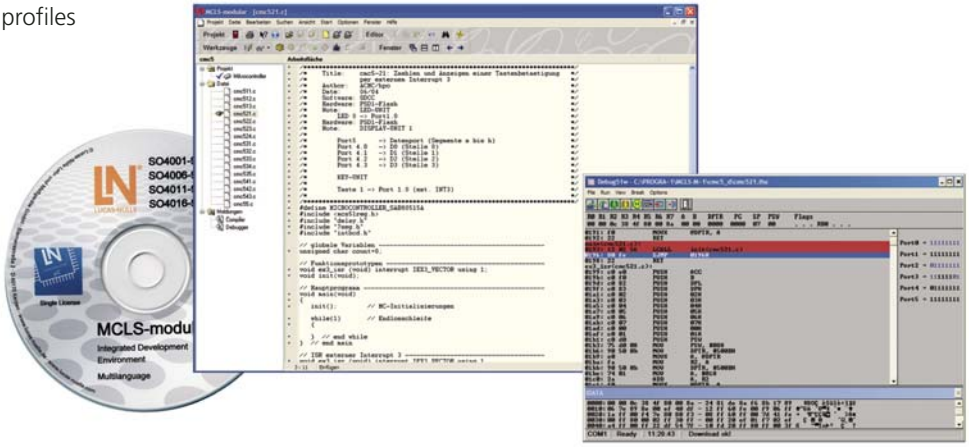
Software components

MCLS-modular® provides comprehensive flexibility and openness in terms of controller programming software:

- Compatible with software from different manufacturers
- Standardised user interface (IDE) for Windows NT, 2000 and XP
- Direct support via Internet
- Maximum repeatability and reliability during training/experiments
- Systematic, clearly arranged, ergonomic experiment platform
- Installable at any PC workstation
- Usable as a development platform

Software

- Assembler and C programming languages are supported
- Integrated functions: assembler, debugger, simulators and compiler
- Project management
- Multilingual program support
- Use of ready-made profiles



Teachware

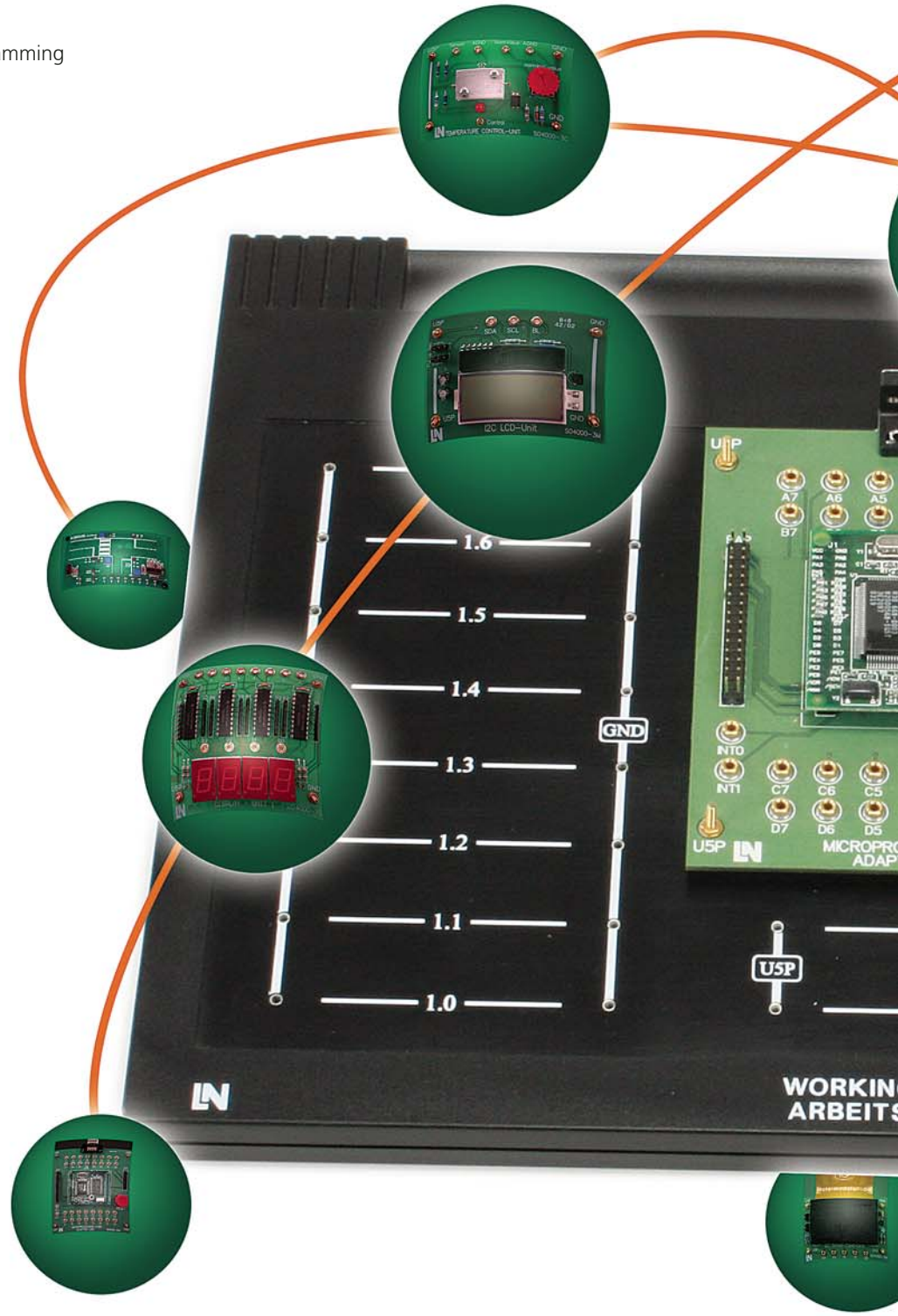
- Large number of courses
- Detailed theoretical sections
- Colour illustrations
- Guided experiments
- Separate "teachers" and "students" sections
- "Teachers" section includes solutions
- Documentation of measurement results
- Tests of knowledge

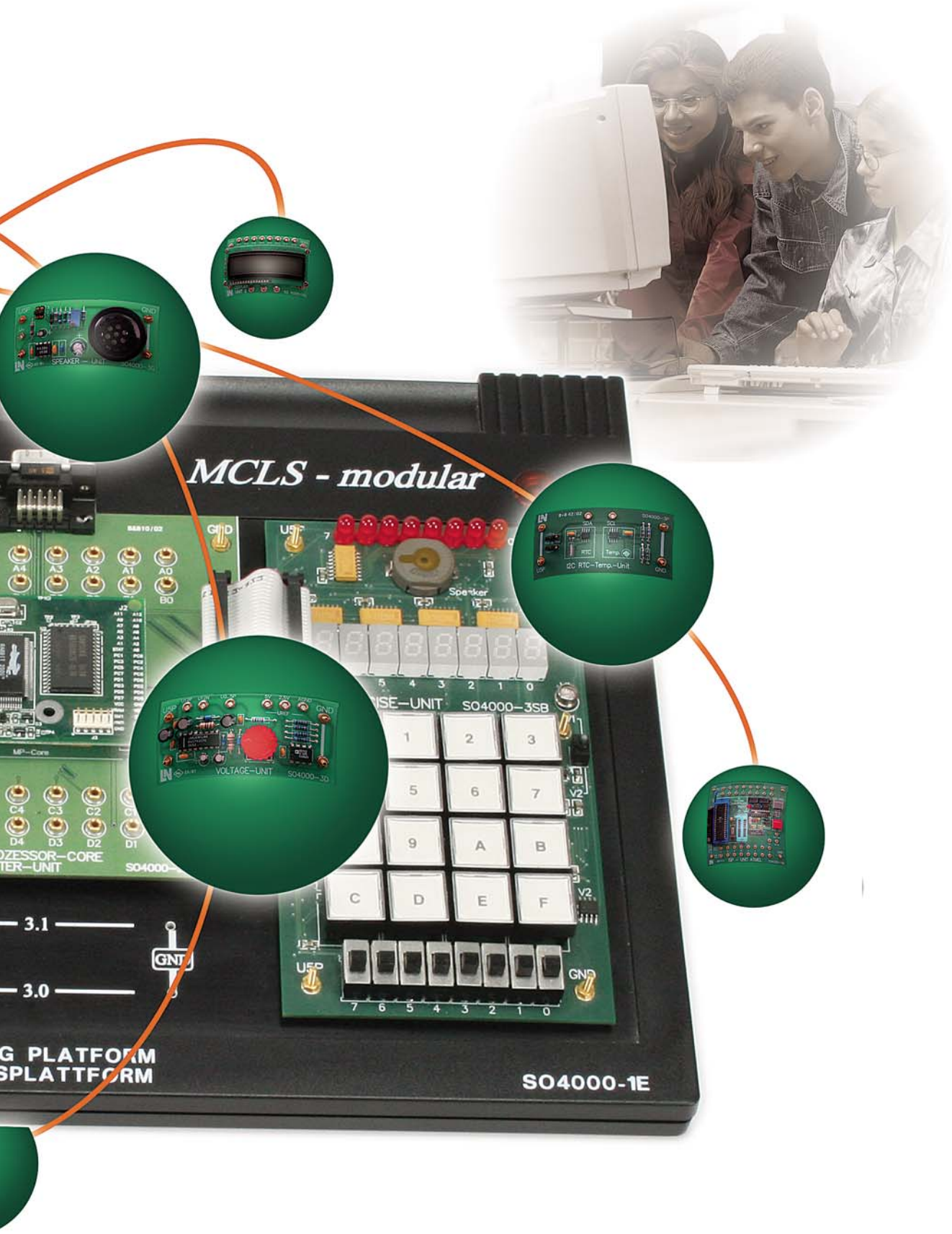
The MCLS-modular® training system

Comprehensive, easy to use, practical

MCLS-modular® imparts a detailed knowledge of the following areas:

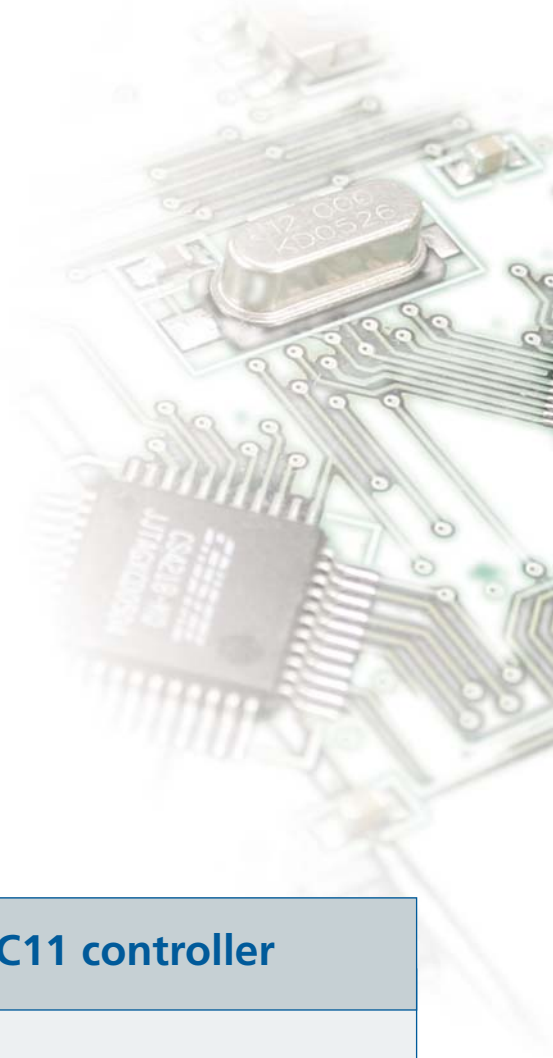
- Fundamentals of microcomputer engineering
- Assembler and C programming of 8051 controllers
- PIC16F84 programming
- Basic course on microprocessor programming
- Digital signal processing (DSP)
- C programming with 32-bit ARM




MCLS - modular
SPEAKER – UNIT
2C RTC–Temp.–Unit
VOLTAGE–UNIT
SO4000–3SB
SO4000-1E

The MCLS-modular® training system

The system at a glance



8051 controller

CMC 5
C programming
of microcontrollers

CMC 4
Programming of data
transfer interfaces

CMC 3
Programming of
on-chip periphery

CMC 2
Applications using an 8051
microcontroller (open-loop
and closed-loop control)

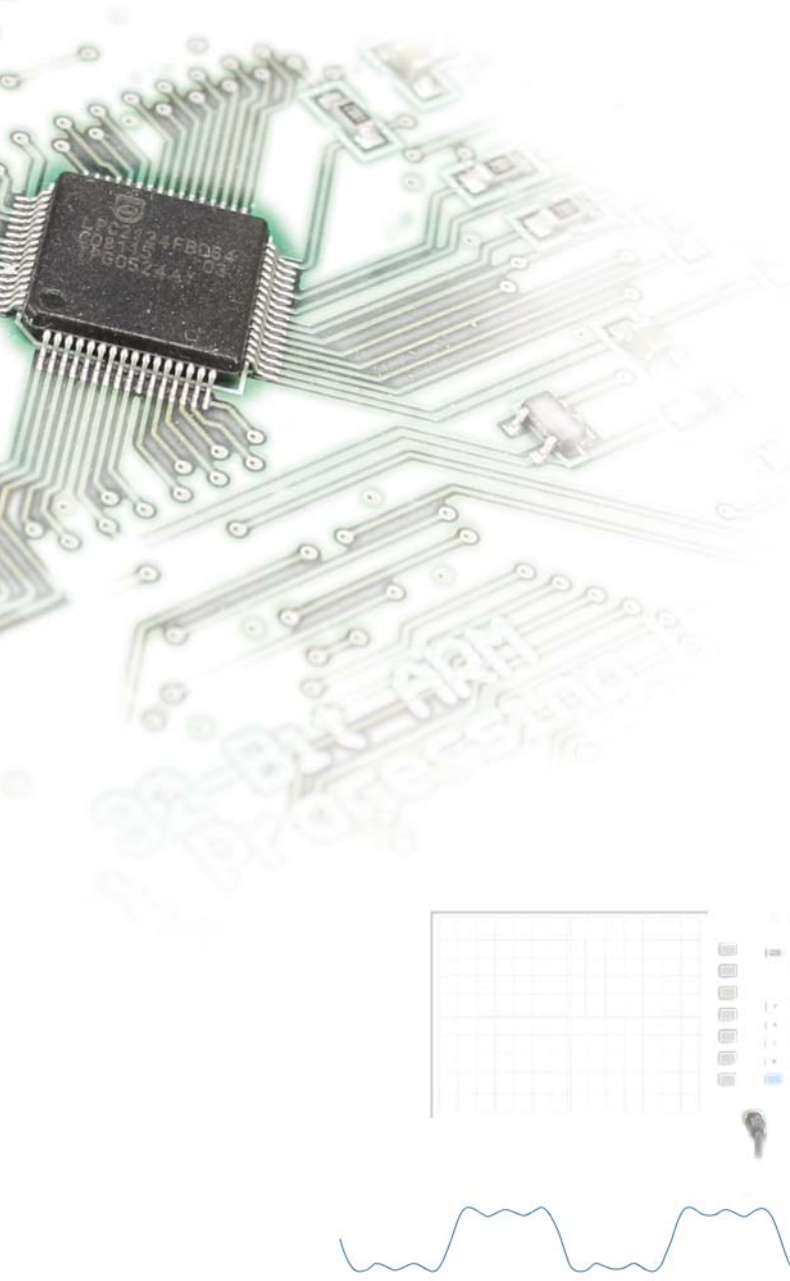
CMC 1
Introduction to programming
an 8051 microcontroller

68HC11 controller

CMC 3M
Programming of
on-chip periphery

CMC 2M
Applications using a 68HC11
microcontroller (open-loop
and closed-loop control)

CMC 1M
Introduction to programming
a 68HC11 microcontroller



DSP/32-bit cores

CMD 2
Applications using digital signal processing

CMC 12
Programming with 32-bit advanced RISC machine cores

CMD 1
Introduction to digital signal processing

Programming for electronic engineers

CMC 10
Programming a PIC16F84 microcontroller

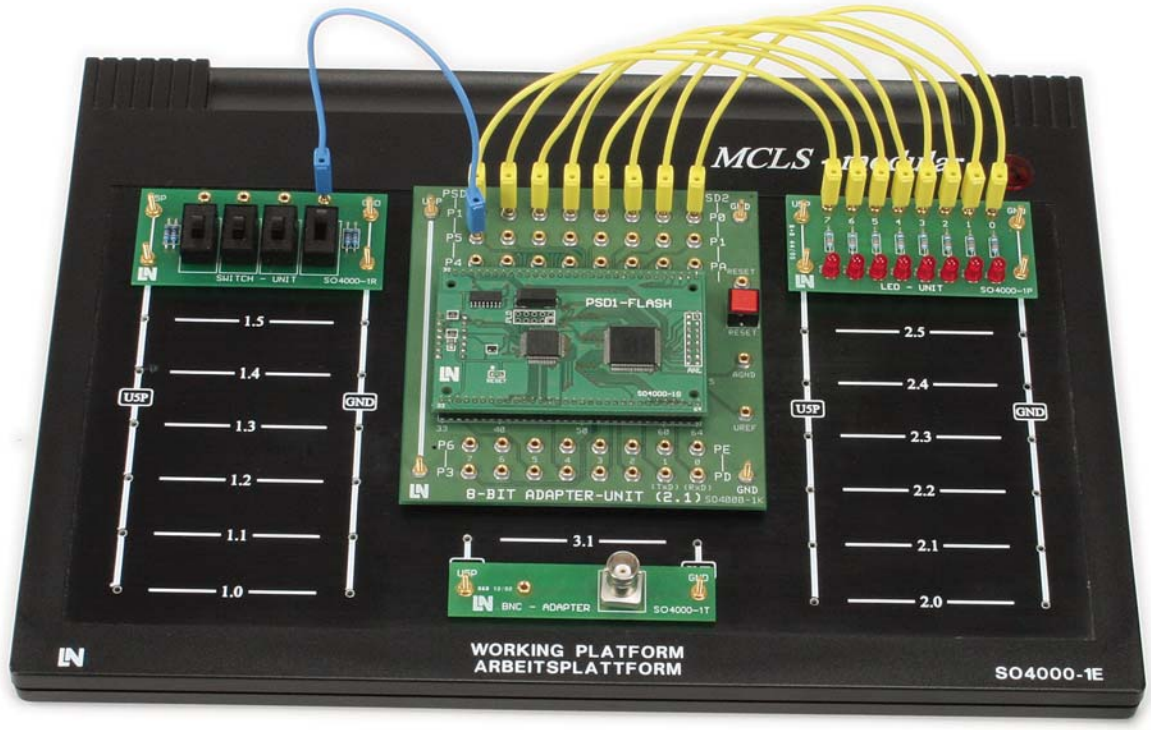
Microprocessor engineering

CMP 1
Basic course Microprocessor engineering

Introduction to microcontroller programming

Basic equipment

Microcontrollers are employed in all areas of electrical and electronic engineering. The widespread use of microcontrollers has made knowledge of their functionality and programming a fundamental prerequisite for technicians and engineers, regardless of their field of specialisation.



Sample experiment from CMC 1

Training and experiment contents

- Design and function of a microcontroller (internal structure)
- Microcontroller operations (timing, ALU, I/O ports)
- Introduction to assembler programming and the development environment
- Introduction to structured programming using the example of lights turned on in sequence
- Microcontroller periphery (ports, clock, reset)
- Memory structure and instruction list for microcontrollers
- Program testing and tracing faults using a debugger (configuration, function step over, step by step tracing, break points)
- Problem analysis: conception, structuring, implementation and testing of programs

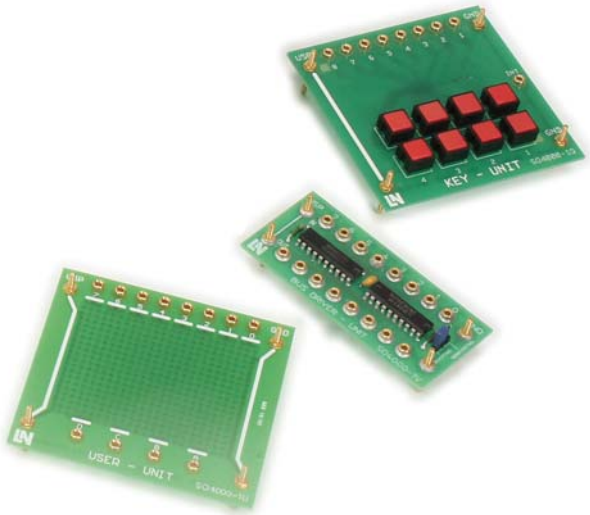
Benefits to you

The module designated "Introduction to microcontroller programming" provides:

- A general introduction to microcontroller functions and programming
- A basic platform which can be scaled up with additional modules to form a complete system for training in microcomputer engineering
- A choice between an 8051 controller or one with a Motorola instruction set

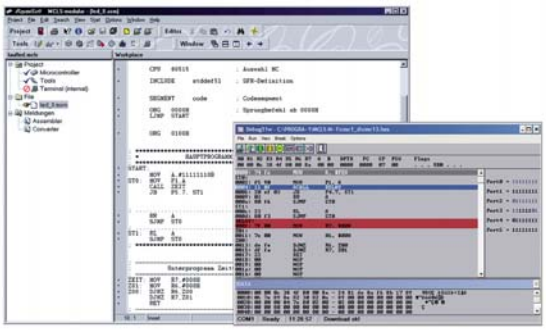
Hardware components in the basic version

- Working platform with power supply unit
- Microcontroller module with adapter
- LED module
- Switch module
- Button module
- Bus driver module
- BNC adapter for connecting external measuring devices



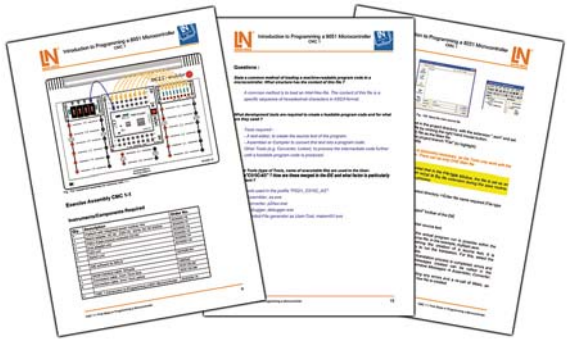
Software components

- Four-language IDE tailored to the requirements of trainees
- The IDE is available with a single/multi-user license, network license for laboratories with networked computers or using hardware dongles for discs
- All development tools are provided and installed automatically



Teachware

- Experiment guide with colour illustrations
- Bound edition
- Includes a CD-ROM with experiment listings and a students' section in PDF format



Ordering details

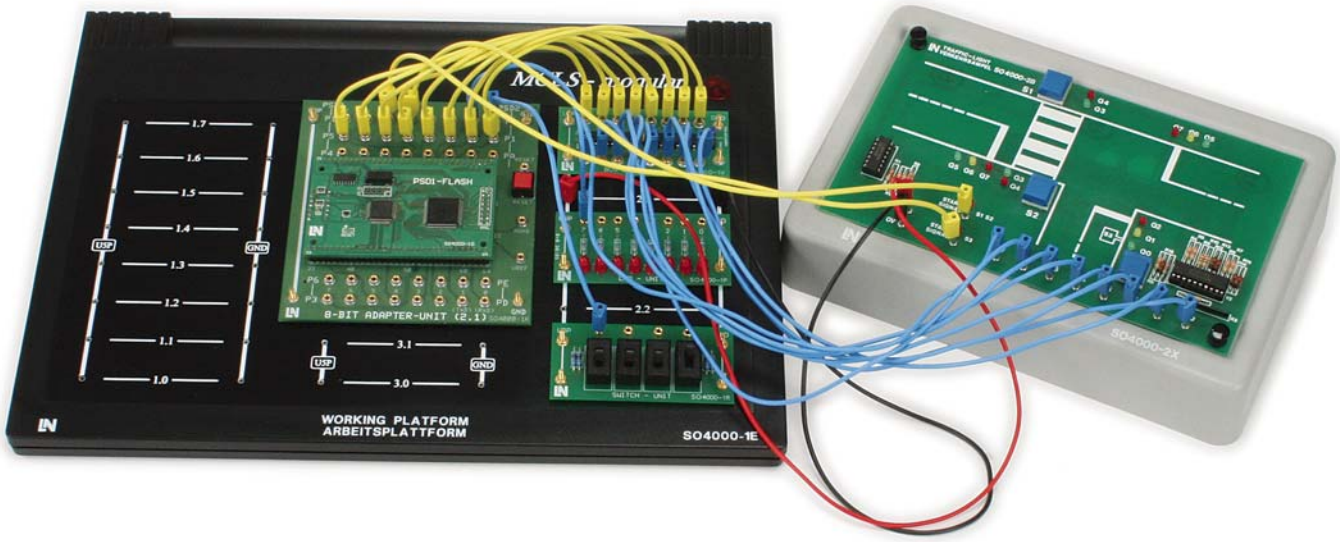
Designation	Reference
Introduction to programming 8051 microcontrollers	CMC 1
Introduction to programming 68HC11 microcontrollers	CMC 1M

Microcontroller applications

Design and implementation

Many processes require open-loop or closed-loop control. PLC units used in production processes commonly employ a micro-controller for controlling electronic devices.

This training module focuses on structured programming intended for complex control tasks. Special application modules are provided to test and visualise processes.



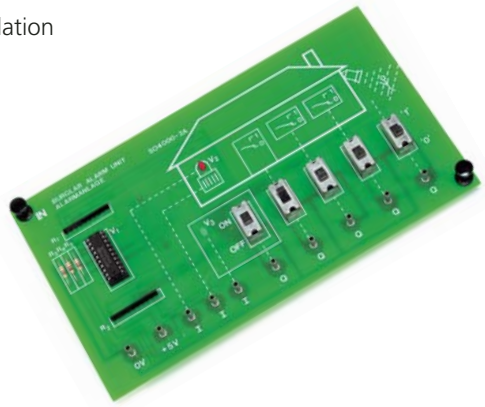
Sample experiment from CMC 2

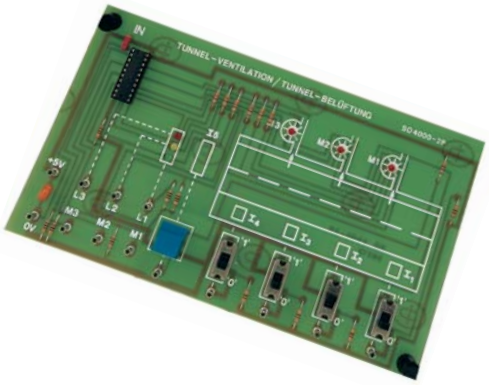
Training and experiment contents

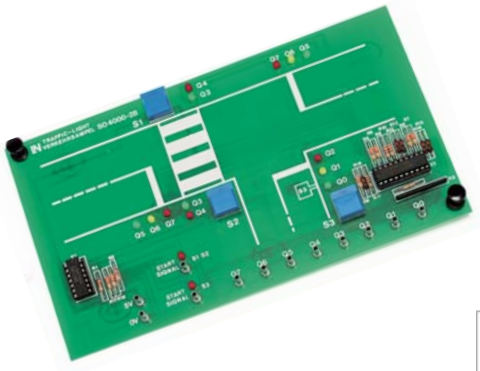
- Introduction to structured programming with simple port operations
- Control of an alarm system using subroutines
- Sequential control of traffic lights using the following key techniques:
  - Data tables
  - Interrupts
  - Continuous and event-based control of sequential processes
- Control of a stepper motor using the following key techniques:
  - Continuous processes
  - Data tables
  - Large numbers
  - 2-byte registers
- Control of a tunnel ventilation system using the following key techniques:
  - Data tables
  - Subroutines
- Control of a mixing unit using the following key techniques:
  - Filling level control
  - Subroutines with transfer parameters
  - Setting of flag bits on key actuation

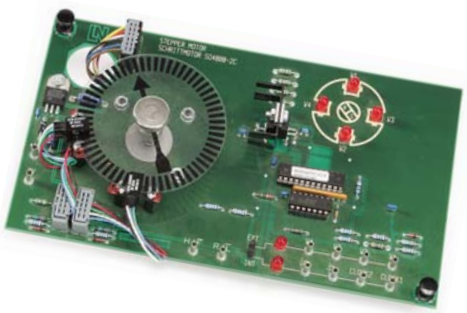
Supplements to the basic kit

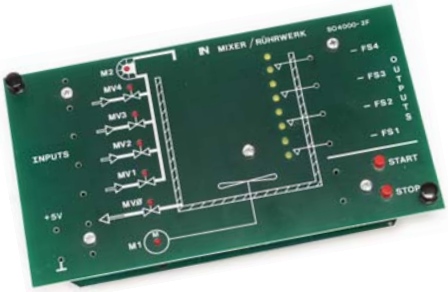
- Model of a building alarm system
- Traffic light model
- Stepper motor with drive module and incremental disc
- Model of road tunnel with 3 ventilation turbines and traffic regulation
- Model of liquid mixing unit (autoclave)
- CMC 2/CMC 2M manual with CD
- Tray for application modules











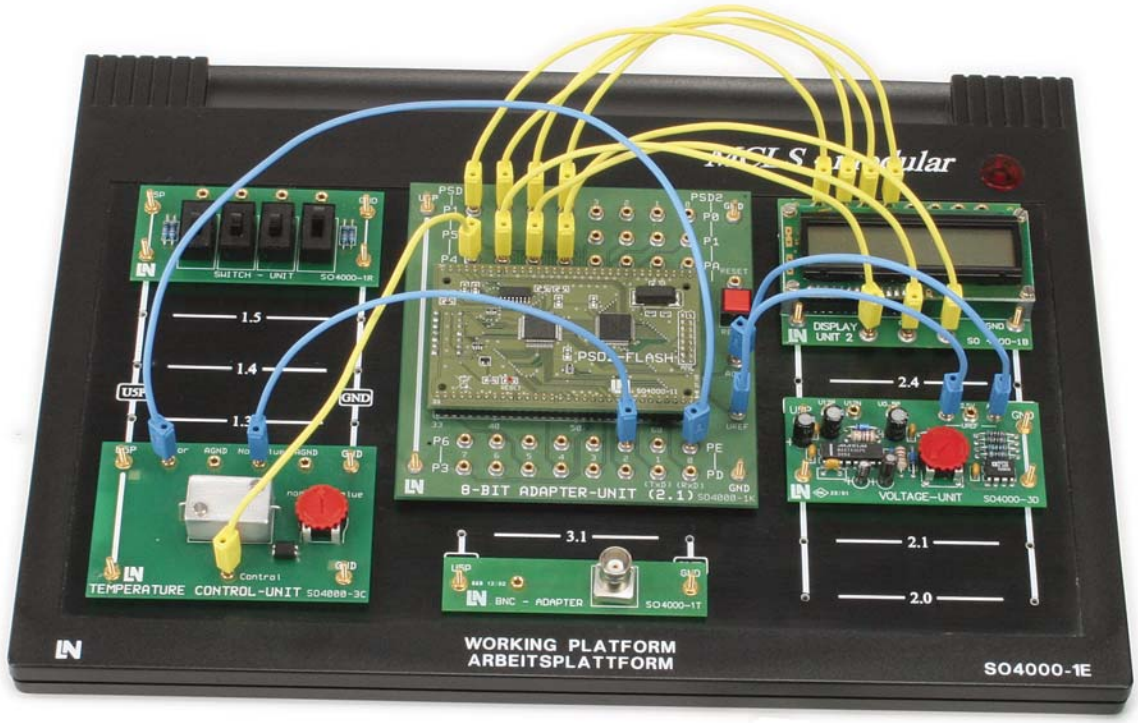
Order details

Designation	Reference
Applications for an 8051 microcontroller	CMC 2
Applications for a 68HC11 microcontroller	CMC 2M

Programming of microcontroller peripherals

On-chip integration

The concept of on-chip integration is intended to boost processing performance and integrate functions while keeping system costs low. It integrates typical peripheral functions for a microcomputer onto the processor chip itself along with the processor core and memory elements.



Sample experiment from CMC 3

Training and experiment contents

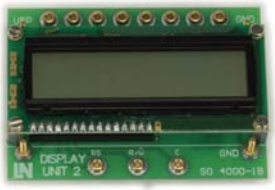
- Introduction to functions and use of interrupts
  - Explanation of an interrupt
  - Interrupt vectors and interrupt vector tables
  - Interrupt handling procedure
  - Interrupt enabling
  - Interrupt priorities
- Timer programming
  - Essential concepts
  - Main components of a timer
  - "Counter" and "timer" functions
  - Auto-reload
  - Compare mode
  - Capture mode
- Analog-digital converters
  - Characteristics of on-chip AD converters
  - Parameters
  - Time ratios

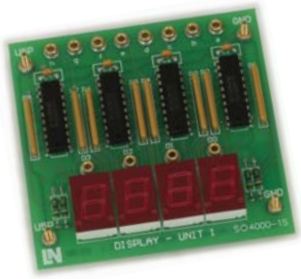
On-chip peripheral components

- Input and output ports
- Timer
- Analog-digital converter
- Communications interface
- External interrupts
- Watchdog timer
- Real-time clock
- Power saving functions

Supplements to the basic kit

- 7-segment display
- Liquid crystal display
- Temperature control module with heating element, temperature sensor and set-point value adjustment
- Reference voltage module
- Loudspeaker module
- Function generator
- CMC 3 manual with CD





Benefits to you

Nearly all of these on-chip components are able to handle interrupts, so the functioning of integrated peripherals can be enhanced by a programmable interrupt system.

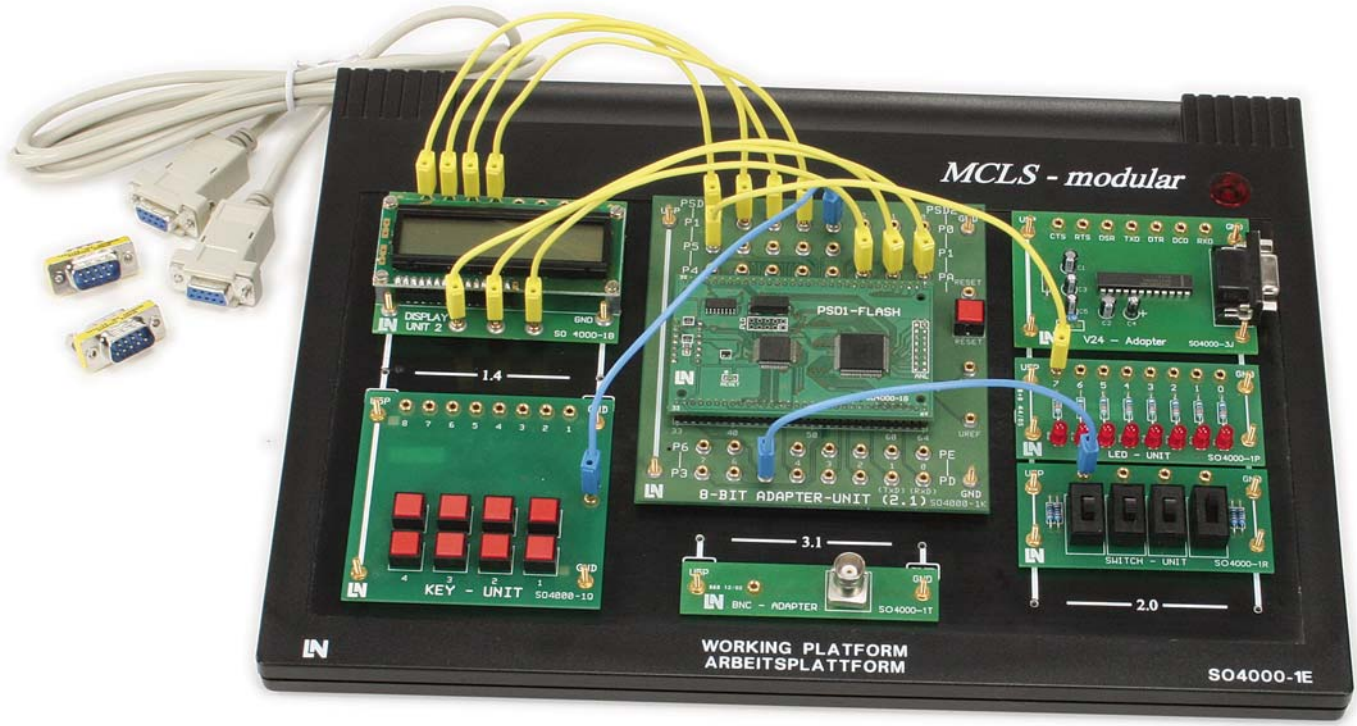
Order details

Designation	Reference
Programming of on-chip peripheral components (8051 controller)	CMC 3
Programming of on-chip peripheral components (68HC11 controller)	CMC 3M

Programming of data transfer interfaces

Serial and parallel interfaces

Transmission of digital information plays a significant role in communications between computers, control units, measuring devices, sensors, actuators and lots of other electronic equipment/components.
Serial communication can be performed using a wide range of techniques, key aspects being synchronisation, signal coding as well as control and security protocols. This module examines some aspects of asynchronous data transmission via RS 232 and V 24 interfaces.



Sample experiment from CMC 4

Training and experiment contents

- Data communication via the microcontroller's serial interface
  - Basic functions (parameters, protocols) for an asynchronous serial interface
  - A microcontroller's asynchronous, serial interface
  - Sample programs for a serial, asynchronous interface (on-chip), e.g. transmission of measurements to a PC
- Serial communication via a V 24 interface between 2 data terminals (with or without hardware handshake)
  - V 24 adapter
  - Software UART
  - Sample programs for an exchange of text messages without hardware handshake or with receive buffer monitoring and hardware handshake
- Data output to a printer via CENTRONICS interface
  - CENTRONICS interface protocol
  - Sample programs for text output and cyclical output of temperature values to a printer

Parallel data transmission takes place via peripheral interfaces such as IEC and CENTRONICS buses, as well as internal communication interfaces such as processor buses and TTL ports. This module examines a CENTRONICS interface as an example of a parallel communications bus.

Supplements to the basic kit

- Liquid crystal display
- Temperature control module with heating element, temperature sensor and set-point value adjustment
- Reference voltage module
- V 24 interface module
- Centronics interface module
- CMC 4 manual with CD

Benefits to you

A null-modem cable set can be used to couple two microcontroller systems and exchange measurement data between them.

Order details

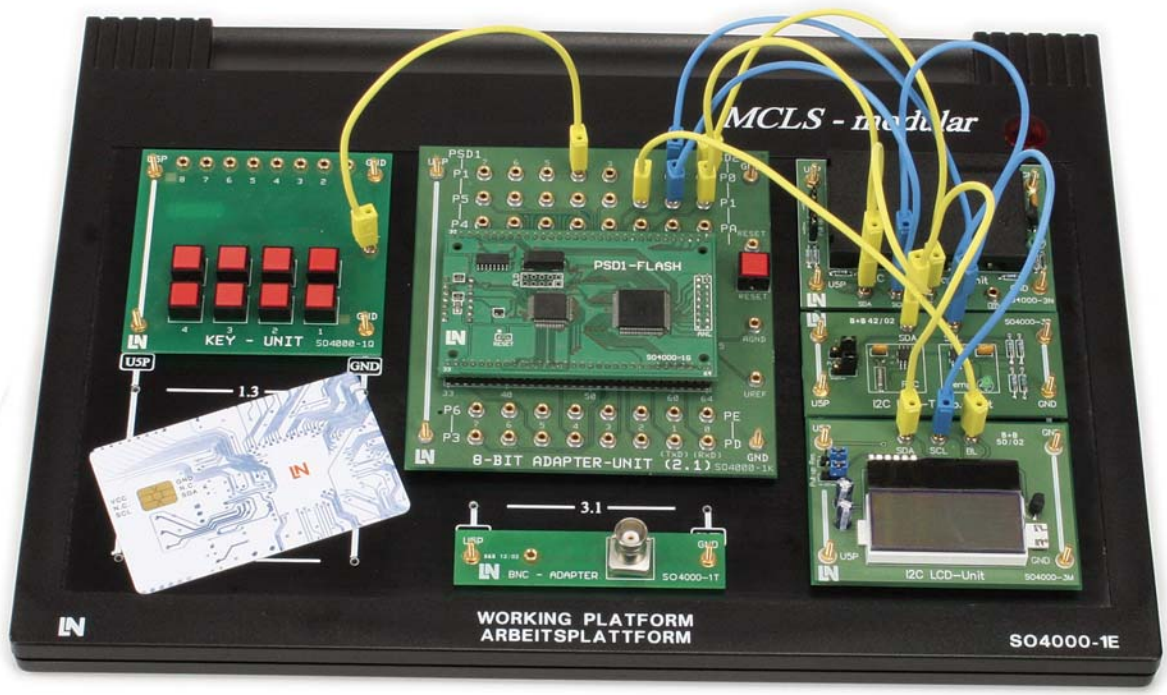
Designation	Reference
Programming of data transfer interfaces	CMC 4

C programming

Programming with high-level languages

High-level languages offer a number of advantages in developing programs for microcontrollers. The main reasons for their use are a high level of abstraction, relatively easy portability of code to various target platforms and the use of software management systems which allow several developers to interact as part of a large project.

Among the high-level programming languages, C is often used for microcontrollers not only because of its general popularity but also because it is hardware-oriented.
C is upwardly compatible with C++. Many compilers are able to generate machine code from both these language variants. Compatibility with C++ permits object-oriented program design.



Sample experiment from CMC 5

Training and experiment contents

- Introduction to the C programming language
- Special aspects of C programming for embedded systems
- Use and operation of a C compiler
- Use of function libraries
- Basic structure of a C program
  - Usage of ports and pins
  - Input and output operations
  - Branches
  - Subroutines
- Interrupts, external interrupts, timers
  - Event counting
  - Display
  - Frequency output
  - Frequency measurement
- I^2C bus
  - Operation and control of an I^2C bus
  - Usage of function libraries
  - LCD control
  - Usage of an AD converter
- Integration of complex peripheral equipment
  - Temperature measurement with an I2C temperature sensor
  - Integration of a real-time clock (RTC)
  - Data storage on chip cards

This experiment module provides a practical introduction to the C programming language, especially as used for microcontrollers forming part of embedded systems. An 8051 controller serves as the target system for the programs to be implemented during the exercises.
Trainees learn the basics of the C programming language in practical experiments making use of modern periphery programming techniques relevant to real-life operations.

Supplements to the basic kit

- 7-segment display
- Reference voltage module
- Loudspeaker module
- Digital/analog converter (DAC)
- I²C LCD unit
- I²C smart card module
- I²C memory cards
- I²C module with real-time clock and temperature sensor
- CMC 5 manual with CD

Benefits to you

In this experiment module, all software development tools such as the compiler are integrated conveniently via software modules into the development environment. This eliminates the need to obtain additional software.

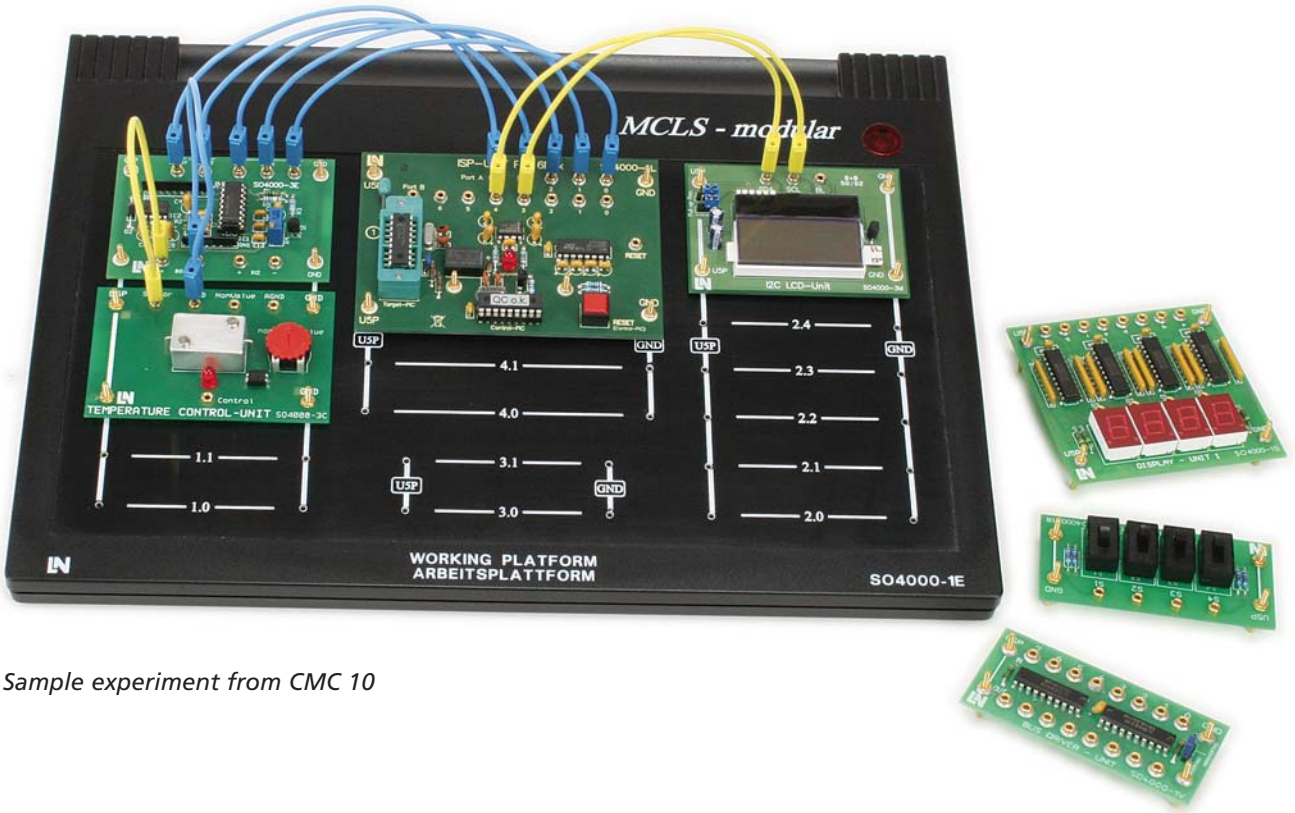
Order details

Designation	Reference
C programming of microcontrollers	CMC 5

Programming for electronic engineers

Programming a PIC processor

Electronic engineers now regularly encounter controllers and processors in the normal course of their profession. Due to their flexibility and performance, these components are increasingly replacing the discrete circuits which were widespread in the past.
This experiment module is intended for trainees in the fields of device and system electronics. Microcontroller applications involving a PIC16F84A instruct students how to configure the software and hardware of component groups.



Sample experiment from CMC 10

Training and experiment contents

- Introduction to the microcontroller
- Introduction to the development environment
- Working with a simulator
- Design and function of a microcontroller (internal structure)
- Memory structure and instruction list for a microcontroller
- Microcontroller programming
- Parallel input/output ports
- Measuring analog values and converting them into digital values
- Output of values (LED/LCD)
- I^2C bus
- Output of values to an I^2C display
- Integrated practical exercises
- Analysis and structuring
- Guided implementation
- Assembly, commissioning and testing
- Integrated tests of knowledge

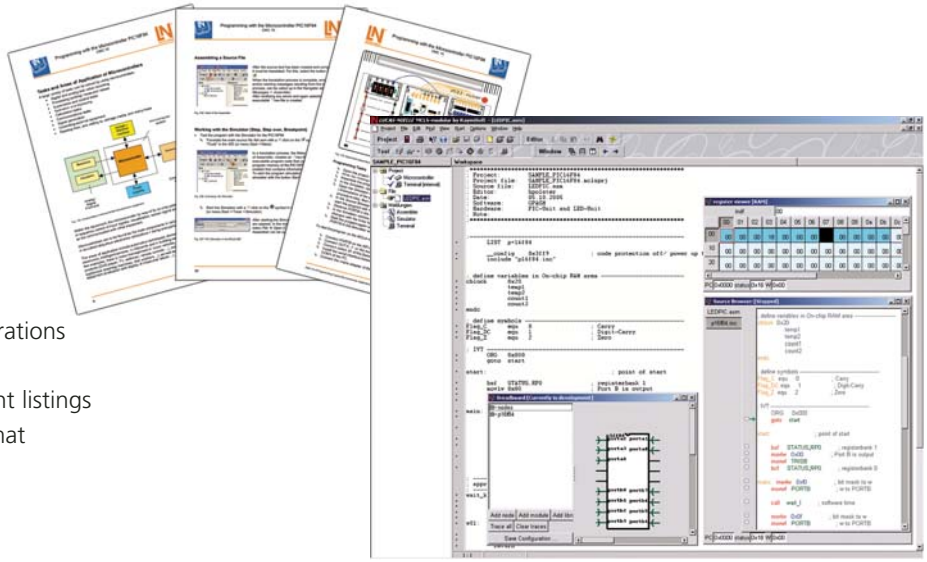
Equipment

"Programming a PIC processor"

- Working platform with power supply unit
- Microcontroller module with programming functionality
- LED module
- Switch module
- Bus driver module
- 14-bit AD converter with SPI interface
- Temperature control module with heating element, temperature sensor and set-point value adjustment
- I^2C LCD unit
- Component kit and PCB
- CMC 10 manual with CD
- IDE on a CD

Software components

- Four-language IDE tailored to the requirements of trainees
- The IDE is available with a single/multi-user license, network license for laboratories with networked computers or hardware dongles for CD-ROM's
- All development tools like the editor, assembler, simulator and programmer are provided and installed automatically

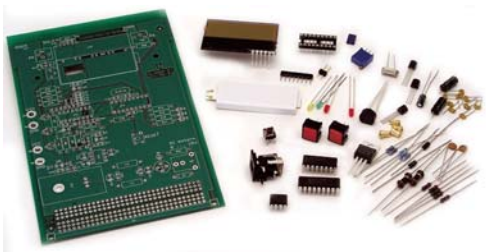


Teachware

- Experiment guide with colour illustrations
- Bound edition
- Includes a CD-ROM with experiment listings and a students' section in PDF format

Project

A practical exercise involving setting up and commissioning an electronic thermometer. All necessary hardware components are provided together with a set of instructions.



Equipment:

- PIC16F84 microcontroller
- Visualisation via 3 LEDs and an I^2C LCD display
- 2 keys for input
- Ambient temperature measurement with an analog temperature sensor
- 14-bit AD converter with SPI interface
- Power supply via mains adapter or laboratory power supply unit
- An optional plug connector permits integration of 19" card slots

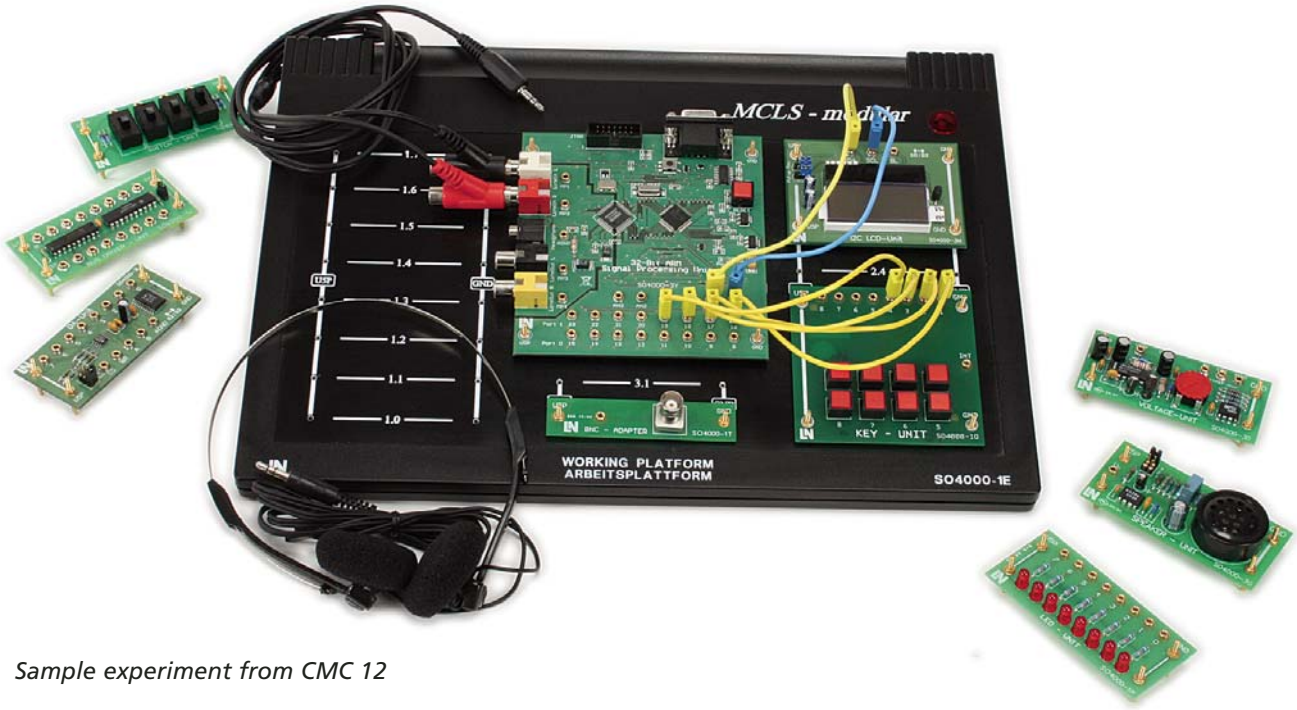
Order details

Designation	Reference
Programming a PIC16F84 microcontroller	CMC 10

Programming with a 32-bit advanced RISC machine core

ARM architecture

Our microcomputer engineering system provides sound training on 32-bit microcontrollers with an ARM core.
This system is ideally suited to higher level education in electrical engineering, communications technology, microsystems and mechatronics.



Sample experiment from CMC 12

Training and experiment contents

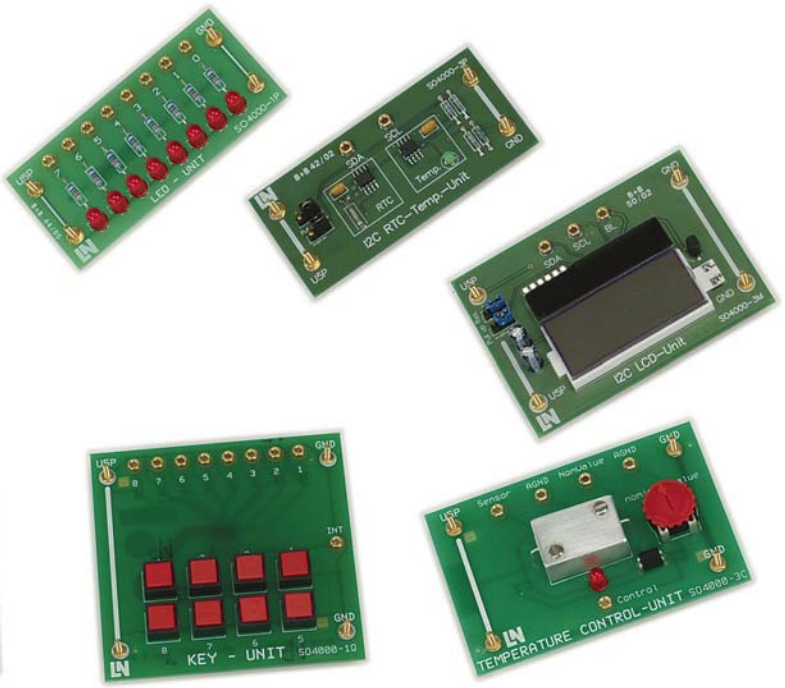
- Introduction to C programming for embedded systems
- ARM architecture
- Simple input and output operations
- Use of subroutines
- Timer programming
- Interrupt control
- Use of on-chip periphery
- Use of CODECs
- Implementation of complex calculation algorithms

32-bit ARM signal processing unit

- 32-bit microcontroller: ARM7TDMI-STM LPC2124
- On-chip memory: 16 kB SRAM/256 kB flash memory
- 18 digital I/O pins
- 4-channel, 10-bit analog to digital converter
- 2 UARTs
- I^2C bus for speeds up to 400 kbits/s
- 2 SPI
- Clock: external 12 MHz with internal PLL up to 60 MHz
- 16-bit audio CODEC CS4218KQ
- Sampling rate: 8 kHz to 48 kHz
- Stereo headphone socket
- Serial interface for ISP programming
- JTAG interface for debugging

CMC 12 equipment

- Platform with mains adapter
- 32-bit ARM signal processing unit
- LED module
- Key unit (8 keys)
- I^2C LCD module
- I^2C RTC temperature module
- I^2C smart card module
- Temperature control module



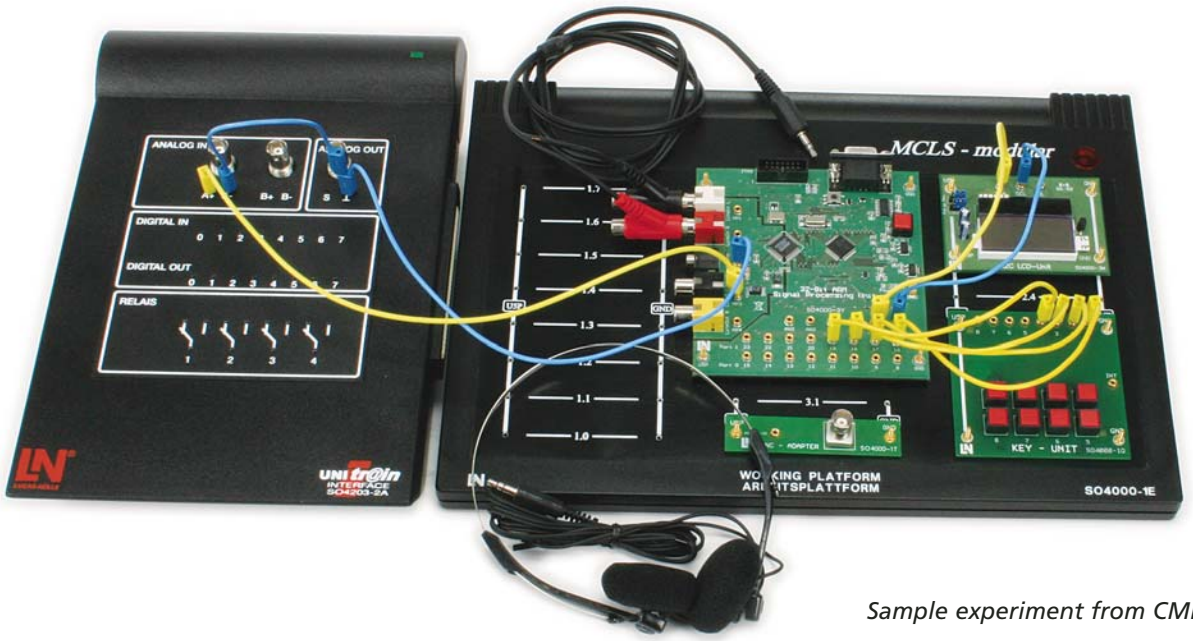
Order details

Designation	Reference
Programming a 32-bit advanced RISC machine core	CMC 12

32-bit microcontroller

Learning with UniTrain-I multimedia courses “Digital Signal Processing 1 and 2”

Digital signal processing (DSP) offers innovative solutions for a wide range of technical processes. Such solutions can be implemented using dedicated digital processors and with numerous high speed microprocessors currently available.
The wide range of applications to which the latter can be applied makes them an attractive alternative to conventional DSPs.
In conjunction with the UniTrain-I multimedia experimentation and training system, clearly structured educational software guides the user through the experiments by means of text, graphics, animations and tests. The UniTrain-I interface can also be used for measurement and testing.



Sample experiment from CMD 1/CMD 2

Training and experiment contents

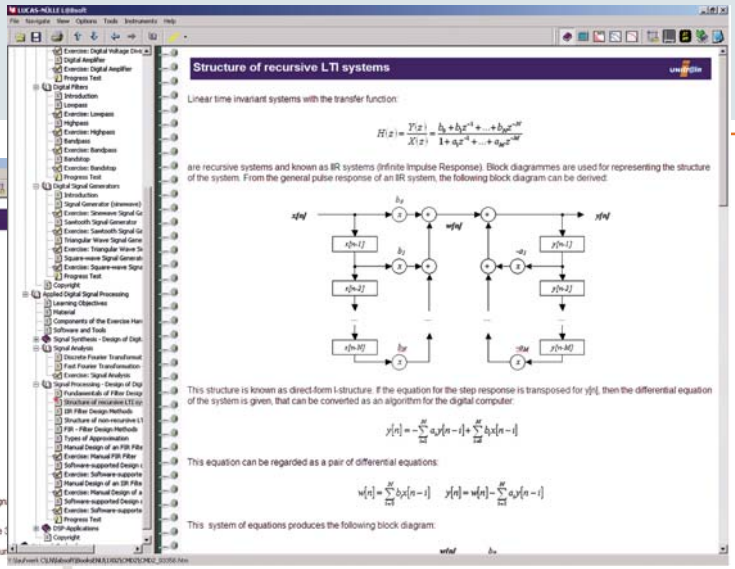
- Introduction to digital signal processing
  - Significance of digital signal processing
  - Digital signal processing components
  - Simple transmission functions
  - Digital filters
  - Digital signal generators
- Applied digital signal processing
  - Design of digital filters
  - Design of digital signal generators
  - Discrete Fourier transformation
  - Selected applications involving digital signal processing

Supplementary kit for CMC 12

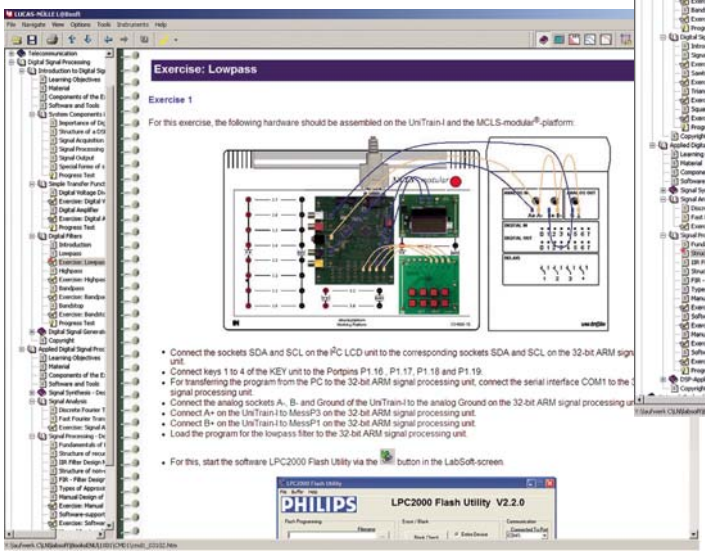
- UniTrain-I interface
- Courses on digital signal processing

Benefits to you

- Combination of cognitive and hands-on educational techniques
- Strong emphasis on theory as well as practice
- Rapid success thanks to well structured courses
- Organisation into:
  - Educational goals and content
  - Hardware descriptions
  - Software descriptions
  - Basic knowledge
  - Experiments
  - Tests of knowledge
- The system is also suitable for demonstration as a component of vocational training courses



Detailed theoretical sections



Experiment set-up

Order details

Designation	Reference
Introduction to digital signal processing	CMD 1
Applications involving digital signal processing	CMD 2

Microprocessor engineering

Application-specific experiments

Besides microcontrollers, microprocessors also form part of industrial applications. Classic processor variants such as the 8085, 8086, Z80 and 68000 live on in modern industrial processors in the form of their numerous derivatives.
Modern processors for personal computers have become highly specialised and are seldom found any more in industrial devices.

Sample experiment from CMP 1

Training and experiment contents

- Registers
- Instruction set
- Flags
- Addressing modes
- Stack functions
- Subroutines
- Interrupts
- Bus functions

Benefits to you

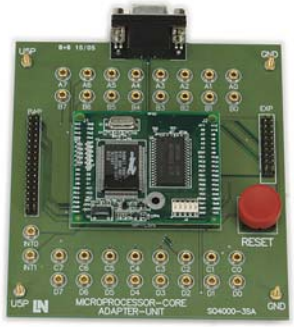
- Introduction to elementary components and functions through simple programming exercises
- Major emphasis on practice by means of appropriate experiments such as measurement, evaluation and indication of physical parameters
- Usage of assembler, showing how the functioning of the processor is directly related to the action of the program

Equipment

- Working platform with power supply unit
- 16-bit microprocessor
- Experiment module
- Bus analyser
- CMP 1 manual with CD
- IDE on CD

Processor

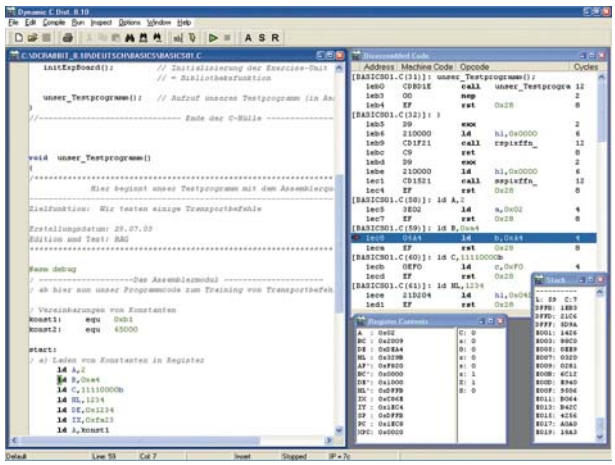
- Z-80 derivative
- 4 different interrupt priorities
- Additional RAM or FLASH modules can be connected directly to the processor
- Cold start capability
- 40 parallel I/O channels (shared with serial ports), some controllable by timer
- 4 serial ports with high baud rates (1/32 of processor frequency)
- Integrated clock with back-up battery
- Total of six different timers and counters for handling interrupts, baud rates and pulses



Software environment

As well as experiment hardware, software development tools are also needed for conducting the experiments in this course. The professional C development environment selected for this purpose provides all the components necessary for writing programs:

- Editor
- Compiler
- Assembler
- Debugger
- Help function



Order details

Designation	Reference
Basic course on microprocessor engineering	CMP 1

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