Human Interface Module 02/10
# Hardware Reference
Release 1.4a (October 11, 2017)

Purpose:
Basic manual interaction (input / output) with microcontroller systems, characterized by simplicity of interfacing, programming, and operation. The module features six keys, one incremental encoder and a dot-matrix LCD display with four rows of 20 characters.

- PCB dimensions: approx. 92 by 156 mm (approx. 4" by 6 6,3").
- PCB fits on a sloped enclosure TEKO 362 and on frames for DIN rail mounting (the latter only if the incremental encoder fits between the bottom of the mounting frame and the PCB, or is not inserted at all).
- PCB can be stacked upon other modules having the same dimensions.
- Microcontroller interface: only one 8-bit port. Four bits data bus (bidirectional) + four control signals (outputs).
- Supply voltage: 5 V. Tolerances according to specifications of the LCD display.
- LCD display: Dot-matrix, 4 rows of 20 characters. Controller: KS0073. Example: EA DIP204B-6NLM.
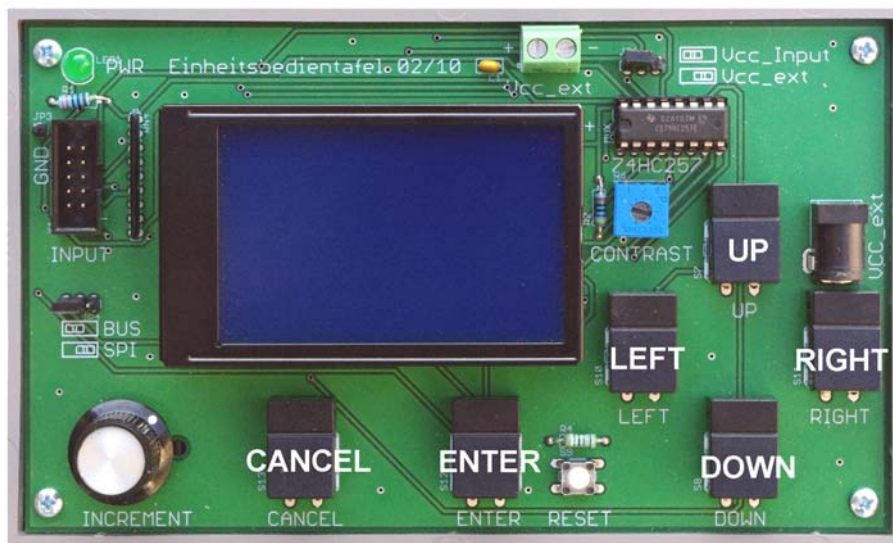
Fig. 1 The human interface module 02/10. The key designations refer to a preferred use.
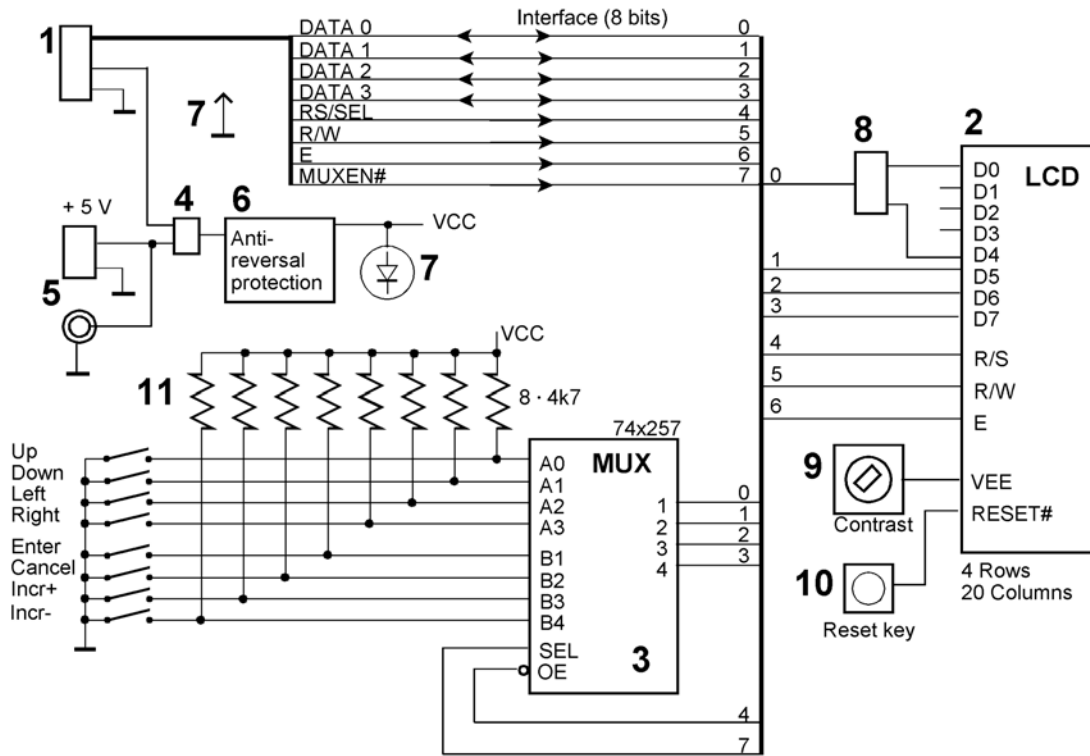
Fig. 2 Human interface module 02/10 block diagram.

Principles of Operation

The 8-bit interface comprises a bidirectional 4-bit bus and four control and strobe signals. The dot-matrix display is operated in the 4-bit mode. The keys and the incremental encoder are attached via a multiplexer with three-state outputs. The 8-bit interface comprises a bidirectional 4-bit bus and four control and strobe signals.
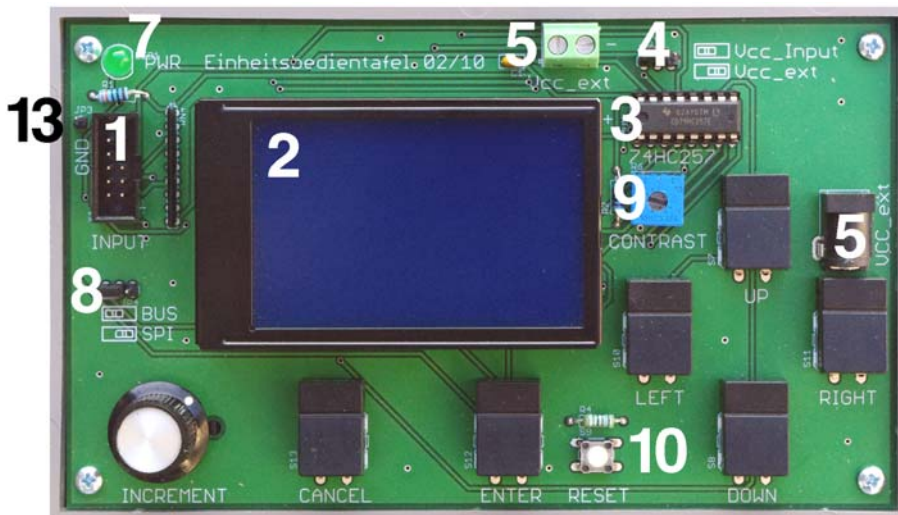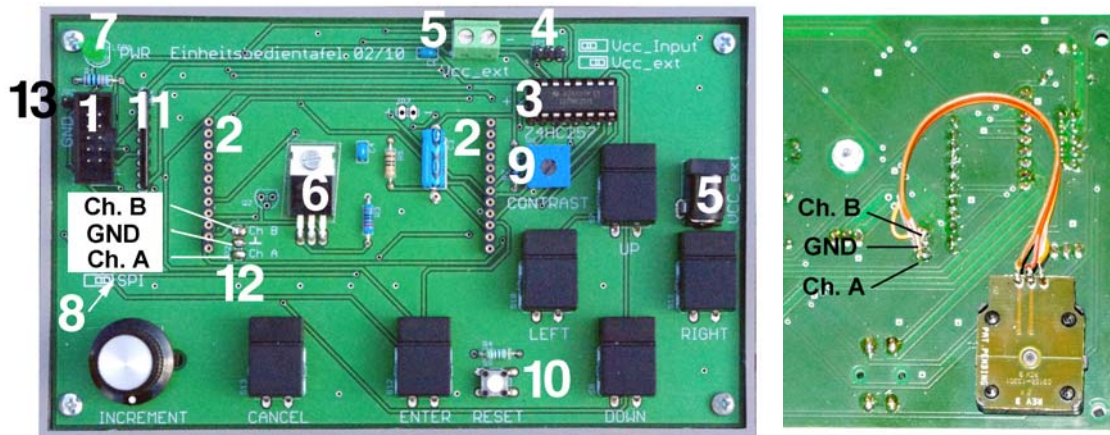
1	I/O port connector (header)	8	LCD display interface mode select jumper (JP2)
2	LCD display	9	Contrast adjustment
3	Multiplexer	10	LCD display reset key
4	Power supply select jumper (JP1)	11	Pull-up resistors (SIP)
5	Power supply connectors	12	Attachment of the incremental encoder
6	Antireversal protection	13	Ground test point
7	Power LED		

Fig. 3 The human interface module 02/10.

I/O port connector (1)

The I/O connector is a pin header with 10 pins in two rows and a pin pitch 0f 2,54 mm (100 mil). Various types can be inserted (horizontal or vertical, on the component side or on the soldering side, shrouded or not and so on). The assignment of the I/O signals, GND and VCC corresponds to the industry standard of the Atmel starter kits and the like (Fig. 4). The GND and VCC contacts can be used to feed the module power or to power the upstream device.

2	4	6	8	10
Bit 1	Bit 3	Bit 5	Bit 7	VCC
Bit 0	Bit 2	Bit 4	Bit 6	GND
1	3	5	7	9

Fig. 4 I/O port header pin assignment.

LCD Display (2)

Dot-matrix, 4 rows of 20 characters. Controller: KS0073. Example: EA DIP204B-6NLM. The LCD display can be operated alternately in SPI mode. Jumper JP2 (8) is to be inserted according to the selected mode.

Multiplexer (3)
The keys and the incremental encoder are accessible via a multiplexer with three-state outputs. The multiplexer drives a 4-bit data bus. If the multiplexer is disabled (signal MUXEN# on high level), then the data bus is free for accessing the LCD display. If the multiplexer is enabled (signal MUXEN# on low level), four of the contact signals are driven to the data bus.
The basic type is 74x257 (quadruple 2-line to 1-line, tri-state outputs). A TTL or 5-V CMOS type may be inserted. Speed (propagation delay) does not matter.

Power Supply Jumper (4)
This jumper selects the power source. Power can be fed via the power terminals (5) or the I/O port conector (1). Fig. 5 illustrates, how the power configuration is to be set:

a) Jumper to the left. The power rail is connected to the power contacts of the I/O port connector (1). The device connected upstream will feed the module.

b) Jumper to the right. Power will be delivered via one of the power-supply connectors (5).

c) A special jumper with three contacts is necessary if the power is to be delivered via a power-supply connector, and if the device connected upstream is to be powered from the module.

Fig. 5 Power supply jumper settings. a) Module powered by upstream device. b) Module powered via power-supply connectors. c) Module powers upstream device.

Power Supply Connectors (5)
Power must be supplied from outside. The board has no voltage regulator. Supply voltage VCC = 5 V. The LCD display requires somewhat close tolerances. Power can be fed into the module via the power connectors (terminal block or coaxial jack) or via the I/O port connector. The power source is selected by jumper JP1.

Antireversal Protection (6)
The venerable circuit invented by Bob Pease protects the module against polarity reversal. The components are located beneath the LCD display.

Note: The antireversal protection depends on a P-channel FET with low R_{DSon} and low V_{GTH}. If the voltage drop cannot be tolerated, antireversal protection is to be abandoned. In this case, do not insert a FET, but a jumper wire from drain to source.

Power LED (7)
One of the most basic troubleshooting aids is an indication, whether a device is powered or not.

LCD display interface mode select jumper (8)
The LCD display can be operated alternatively in bus mode or in serial mode (SPI mode). To select the desired mode, the LCD display has a solder pad at its back side (cf. LCD data sheet). The manufacturer's default mode is the bus mode. Both modes can be implemented by microcontroller programming. However, the LCD display emits the SDO signal via the data bus D0 pin. Therefore, LCD configuration by soldering must be supplemented by appropriately setting the jumper JP2:

- to the left, if bus mode is to be selected,
- to the right, if SPI mode is to be selected.

Contrast adjustment (9)
LCD contast can be adjusted by means of a trimpot.

LCD display reset key (10)
As experience shows, a reset key is an inexpensive, but convenient means to facilitate debugging and troubleshooting.

Note: Program faults may occur, from which the LCD display cannot recover except by hardware reset. The reset input is an unique feature of this particular LCD display. Most LCDs have no reset input, so the only means to initiate a hardware reset would be cycling power. If only proven software will be used, the reset key may be omitted.

Pull-up resistors (11)
The contacts of the keys and the incremental encoder are connected to pull-up resistors in a single-inline package (SIP).

Attachment of the incremental encoder (12)
The incremental encoder is to be connected by wire.

Ground Test Point (13)
A ground test point can be inserted to support oscilloscope attachment and the like.

The Programming Interface

7	6	5	4	3	2	1	0
Control Signals			Mode	Data Bus			
– Output –				– Input or Output –			

Fig. 6 How the I/O signals are to be used.

7	6	5	4	3	2	1	0
E	R/W#	R/S/SEL	MUXEN#	LCD_D7	LCD_D6	LCD_D5	LCD_D4
SCLK	SID	CS/SEL	MUXEN#	–	–	–	SOD

MUXEN#:   Multiplexer output enable (0 = active (outputs to bus); 1 = inactive (third state, high Z).
SEL: Multiplexer select input.

Fig. 7 LCD display signals. The last row relates to the SPI mode.

7	6	5	4	3	2	1	0
0	– *	0	0	RIGHT#	LEFT#	DOWN#	UP#
0	– *	1	0	INCR DOWN#	INCR UP#	CANCEL#	ENTER#
– Output –				– Input –			

*: Don't Care.

Fig. 8 How the inputs are scanned. MUXEN# = 0. The multiplexer drives the data bus. Bit 5 (SEL) selects a group of four inputs. The inputs are low active.

7	6	5	4	3	2	1	0
E	R/W#	R/S	1	LCD_D7	LCD_D6	LCD_D5	LCD_D4
– When the LCD display is never read back, all bits can be programmed as outputs. –							

R/S: LCD register select. 0 = command register; 1 = data register.
R/W#:   LCD Access. 0 = write; 1 = read.
E: LCD Enable. 0 = no LCD access; 1 = LCD access (E acts as a strobe or clock pulse).

Fig. 9 The preferred principle to control the LCD display. MUXEN# = 1. The LCD display uses the data bus. Its direction depends on the signal R/W#. When the LCD display is programmed the most basic way, there are only output operations.

7	6	5	4	3	2	1	0
SCLK	SID	CS	1	–	–	–	SOD
– Output –							– Input –

SCLK: Serial clock (output)   *CS:*   Chip select (output)
*SID:*   Serial data input   *SID:*   Serial data input

Fig. 10 The LCD display in SPI mode. MUXEN# = 1. Only bit 0 of the data bus is driven. In the microcontroller, the data bus will be programmed as input with pullup resistors activated.

| LCD Pin	Bus Mode	SPI Mode
5	R/S = Port bit 5	CS = Port bit 5
6	R/W# = Port bit 6	SID = Port bit 6
7	E = Port bit 7	SCLK = Port bit 7
15	D0 (unused)	SOD = Port bit 0

Table 1 Bus and SPI mode with respect to LCD display pins.

Human Interface Module 02/10 in Action
– A Photo Gallery –

A microcontroller module and a human interface module constitute a basic embedded system platform with three 8-bit ports freely available.
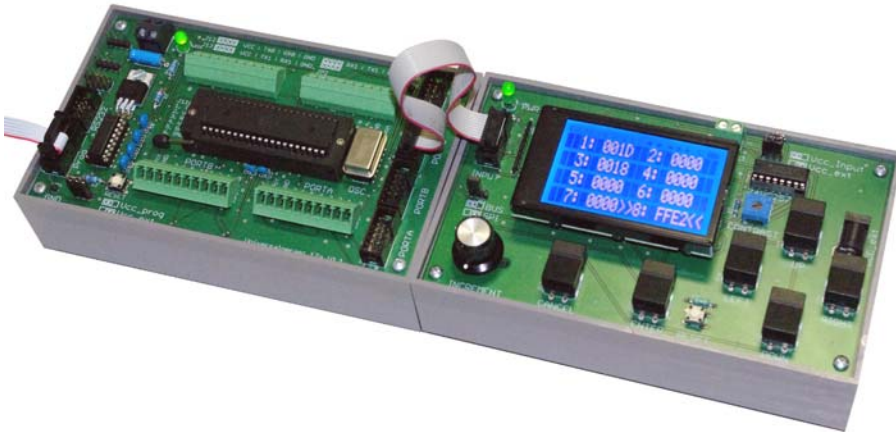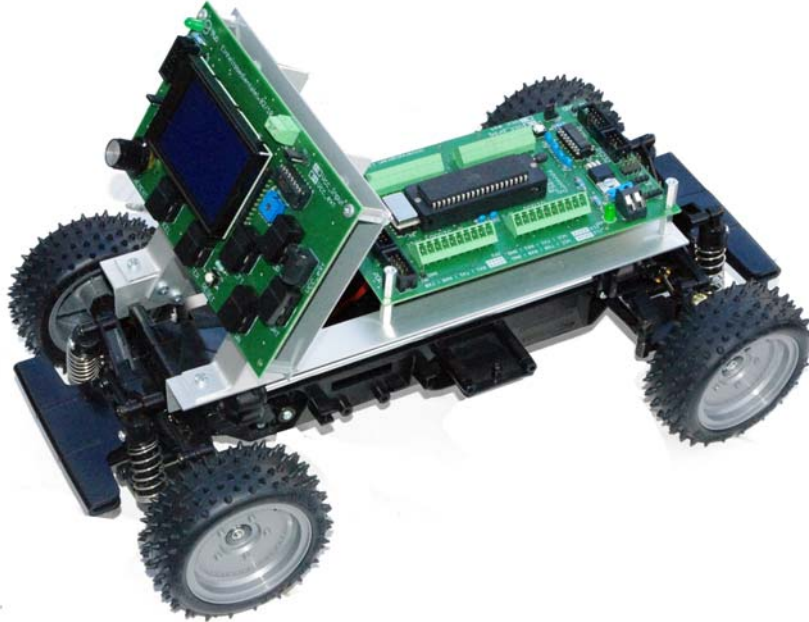
A microcontroller module supports four human interface modules. This ist an educational setup to demonstrate principles of multitasking.
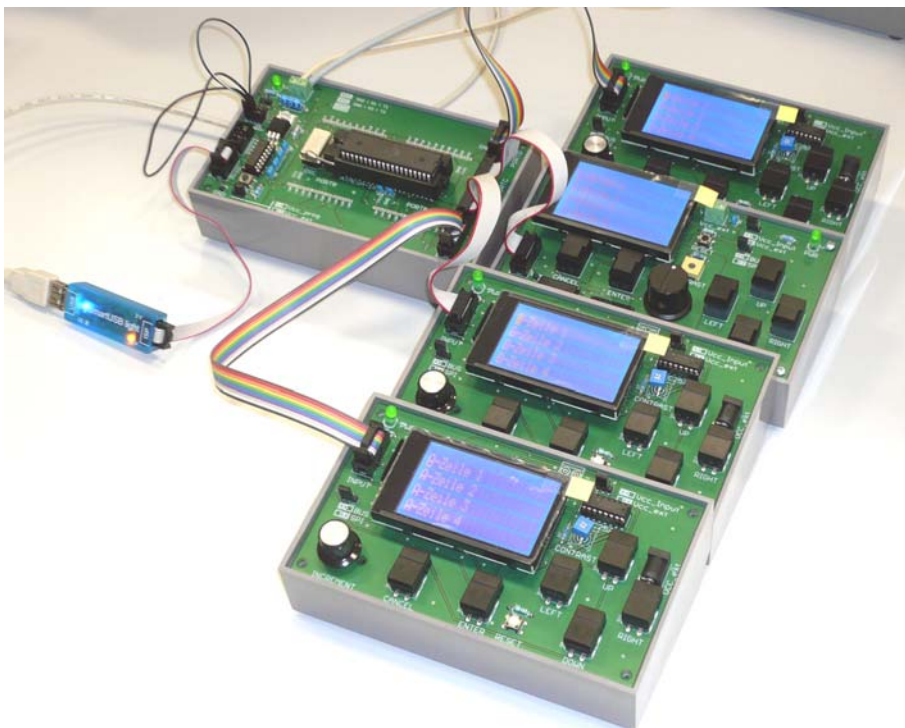
An educational model vehicle shows that the modules can be used as OEM building blocks, too. The purpose of this contraption was to build a platform to facilitate beginners's experiments with robotics. Compared to the ubiquitous small robots on wheels, it should be more sturdy and provide ample expansion space.

The PCB dimensions are well suited to mount modules on a DIN rail. This educational system comprises a microcontroller module, a human interface module stacked above, and an LCD module, carrying a graphical LCD display.
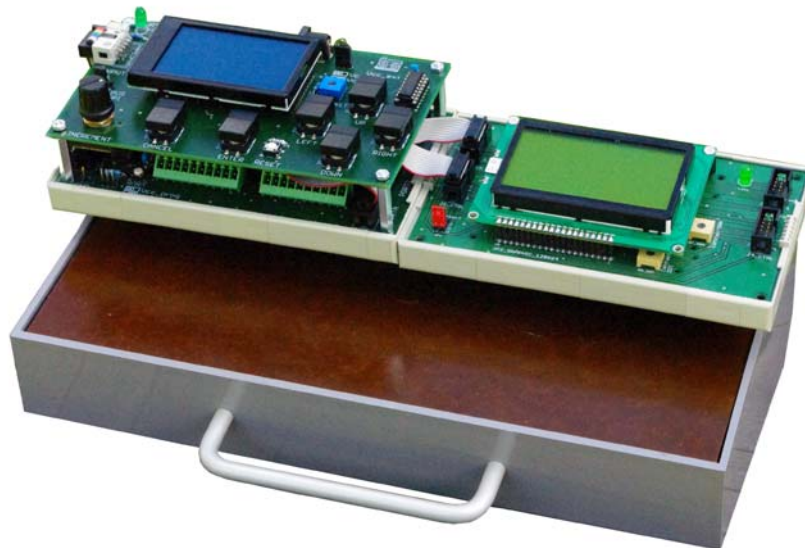
To facilitate the bring-up of a complex experimental multi-microcontroller system, each of the microcontrollers is connected to a dedicated debugging console.
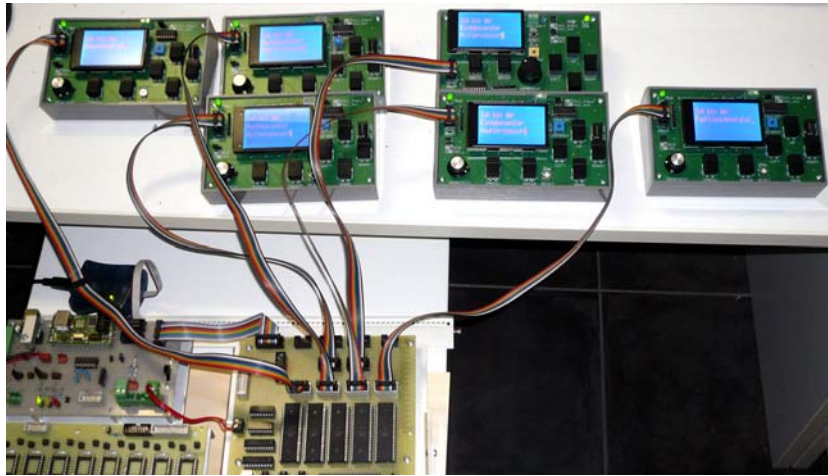

Obviously, the plethora of boxes shown in Photo 8 is much too unwieldy except to troubleshooting tough dogs. During bring-up, two debugging consoles should be sufficient. They are mounted on a front panel in the form factor 19", 3 U, 84 HP, connected to the frame of the machine.

A new kind of module – the Xmega Trainer Type 3 – during bring-up (the second box from the left). The setup comprises a general-purpose microcontroller module and two human interface modules.

A dual-processor system during bring-up. The Atmel STK 500 starter kit serves as programmer and power source.
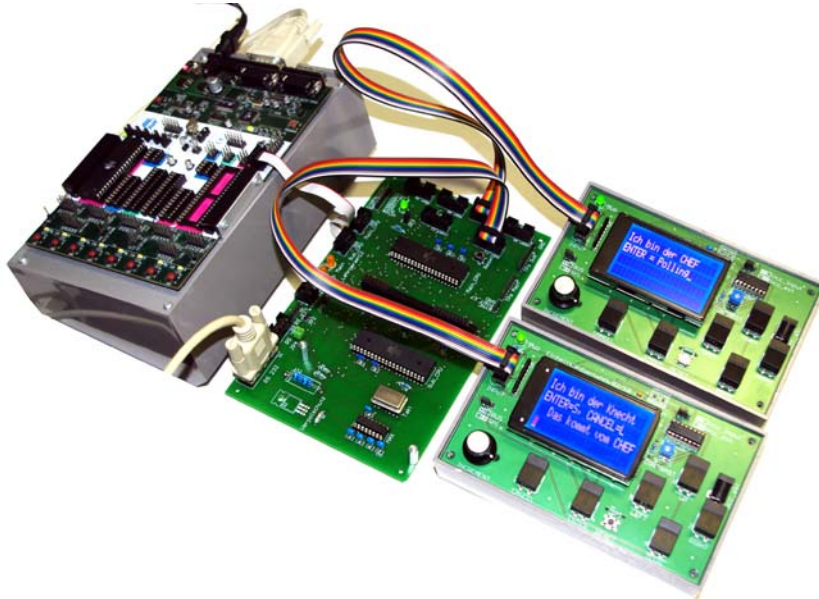
An educational multiprocessor system. Five microcontrollers are connected via a passive hub. Each microcontroller has its own console.