Projects Overview 2016

Release 1.1 (June 24, 2016)

Design Rationale

Most of the projects have been developed for experimental and educational purposes. Except for the purely experimental devices or auxiliary lab equipment, they are well suited as OEM components, too. The basic design rationale is, to build somewhat larger and to use components, which are somewhat more expensive. Most of the projects are principally bricks or modules. With regard to size, sturdiness, and cost, they are placed between the ubiquitous low-cost microcontroller modules and industrial-grade components. As OEM modules, they can be applied in projects, which do not require miniaturization at its utmost. Typical examples are devices in desktop or rackmount form factors, educational vehicles and purpose-built test and research equipment. By selectively populating with components, the printed circuit boards (PCBs) can be adapted to the particular application requirements. Modules with displays, keys and the like can be mounted behind front panels, provided that appropriate connectors are inserted.

Besides that, pursuing such projects is a viable challenge in itself, giving ample opportunities for acquiring hands-on experience at all stages of electronics and embedded system development. Basic design decisisons were made *expressis verbis* with this goal in mind. PCBs should be neither too big nor too small. A large board is costly and not quite handy as a building block for complex systems and OEM use. On the other side, a very small, densely populated board will impede manufacturing, assembly, measurements and rework.

Practical consequences are the decision in favor of intermediate form factors and the restriction to two layers and to components, which can be soldered by hand. PCB routing, component insertion, soldering and the like are possible within the limits of the typical student or ambitious hobbyist, manufacturing within the realm of each run-of-the-mill PCB service provider.

PCBs can be mounted in enclosures or on a chassis. For educational and training purposes, where all components should be accessible easily, a sloped console would be expedient. For most projects, PCB dimensions of approximately the size of a eurocard (about 100 by 160 mm) have found to be appropriate. As the preferred enclosure, the Teko type 323 has been selected. It can accommodate a PC board of approx. 92 by 156 mm (approx. 3 5/8" by 6 5/32"). Such boards fit also nicely into enclosures for DIN rail mounting and behind front panels of 3 U racks.

1. All-in-one Trainers

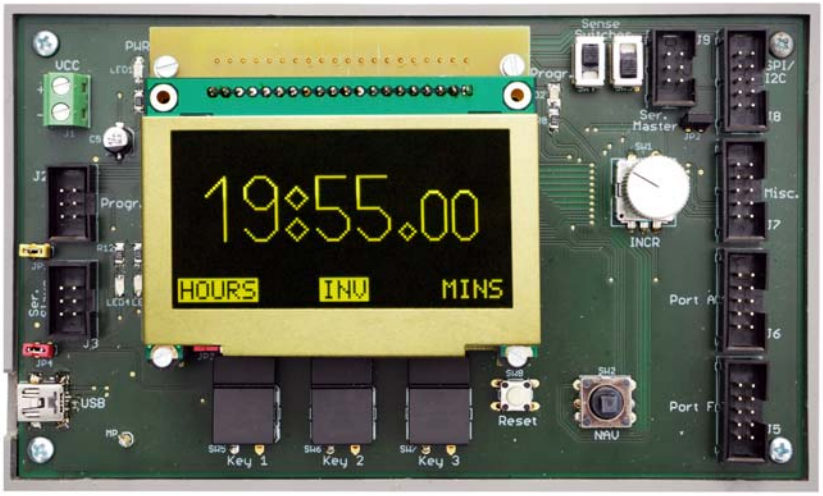
Why tinkering with wires, when one can have all together (so that it will not fall apart)?

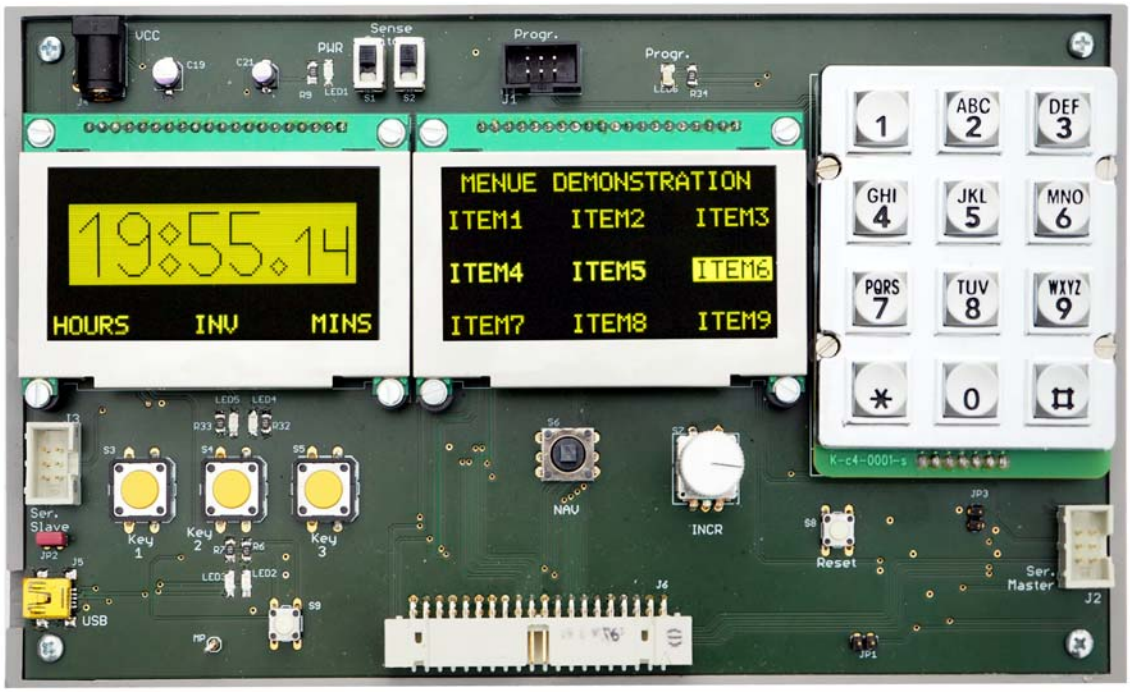
The All-in-One Trainer Type 1 – Single Screen, Single Processor

- Atmel ATmega1281. 5 V supply, 5 V signalization.
- OLED Display 128 * 64 pixels.
- 32 IOs, freely available.
- 2 serial interfaces. 5 V signalization. One of the interfaces with built-in USB converter.
- 3 pushbuttons, 1 incremental encoder, 2 sense switches, 4-directional switch with center push.
- 2-color-LED, piezo buzzer.

The All-in-One Trainer Type 2 – Dual Screen, Dual Processor

- Service processor (SVP): Atmel Xmega64A3U.
- I/O processor (IOP): Atmel Xmega 16A4U.
- 5 V supply. 3.3 V signalization.
- 2 OLED displays 128 * 64 pixels.
- IOP supports 30 IO signals, freely available.
- 2 serial interfaces. 5 V signalization. One of the interfaces with built-in USB converter.
- 3 pushbuttons, 1 incremental encoder, 2 sense switches, 4-directional switch with center push.
- 2-color-LED, piezo buzzer.
- Keypad with 12 keys.
- Bluetooth module.





2. Xmega Trainers

The Atmel Xmega family can be operated up to 3.3 V. The I/O ports and peripherals are somewhat similar to the ports and peripherals of the ARM microcontrollers. Xmega controllers are to be considered, when the applications require sophisticated I/O ports and peripherals. For applications that do not require massive computing performance, Xmega will often be a viable low-cost alternative to 32-bit-microcontrollers (like ARM or PIC32).

Xmega trainers have been developed in two flavours, the "n.A." types (newer) and the "a.A." types (older). "n.A." = neue Ausfuehrung; "a.A." = alte Ausfuehrung. The latter was designed with utmost versatility in mind, including selectable level conversion between 3.3 V and 5 V. However, the PCBs grew way too much complicated. So the newer Xmega trainers were restricted to 3.3-V signalization (except the serial interfaces, which are level-converted to 5 V). Each type has particular peripheral features, aimed at certain fields of application. All newer Xmega trainers have an additional general-purpose expansion connector, allowing installation of piggyback modules or peripheral boards.

The Xmega Trainer Type 1 n.A.

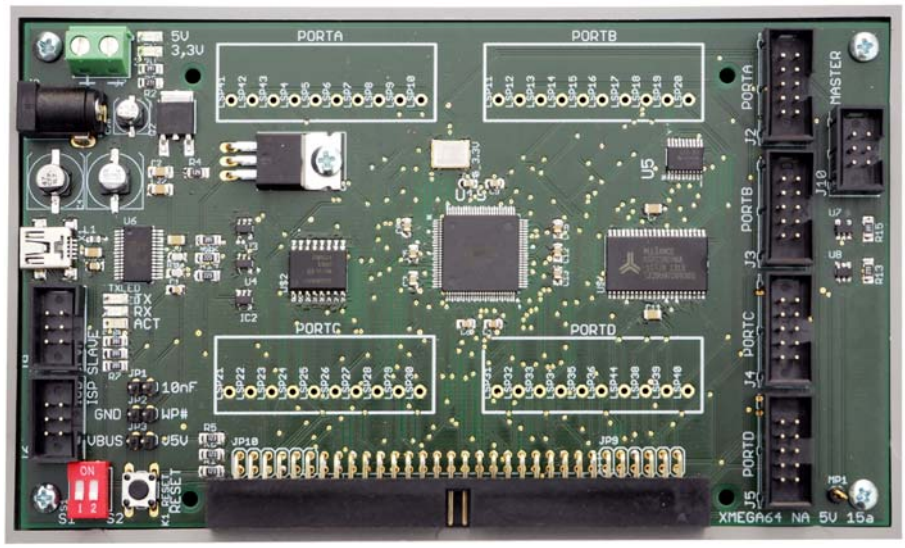
The type 1 n.A. is a general-purpose, low-cost peripheral controller, providing a maximum of easily accessible microcontroller signals.

The photos show the first prototype (V1). Further development led to omitting the RS-232 signalization, reducing the number of jumpers to two, and changing the USB connector to mini-B.

- Processor: Atmel Xmega64A3U.
- 5 V supply. 3.3 V signalization.
- Two serial interfaces. One 5-V slave (downstream), one 5-V master (upstream).
- Serial slave interface with selectable USB converter.
- Two sense switches, programmable bi-color LED.
- Four I/O ports accessible via pin headers and terminal strips.
- Up to 46 I/O signals accessible via the general-purpose expansion connector.

The Xmega Trainer Type 2 n.A.

The type 2 n.A. is a general-purpose microcontroller module with enhanced memory capacity. It is similar to type 1, but with additional 1 MBytes of SRAM and 64 MBytes of Flash ROM.



The photos show the first prototype (V1). Terminal strips not inserted.

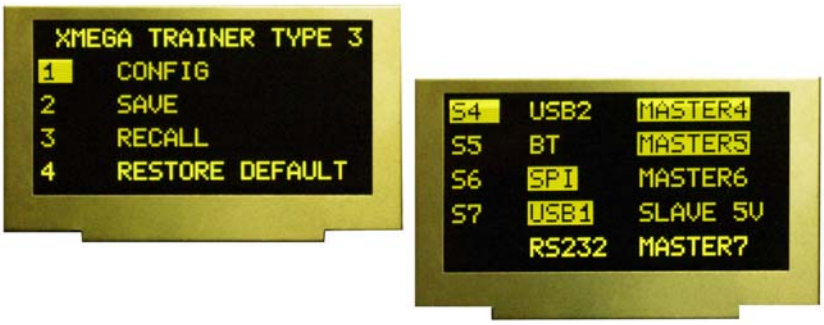
- Processor: Atmel Xmega64A1U.
- 5 V supply. 3.3 V signalization.
- Two serial interfaces. One 5-V slave (downstream), one 5-V master (upstream).
- Serial slave interface with selectable USB converter.
- Two sense switches, programmable bi-color LED.
- Four I/O ports (8 bits) accessible via pin headers and terminal strips.
- Up to 46 I/O signals accessible via the general-purpose expansion connector.
- SRAM 1M • 8.
- Serial NOR Flash 64 MBytes with SPI interface.

The Xmega Trainer Type 3 n.A.

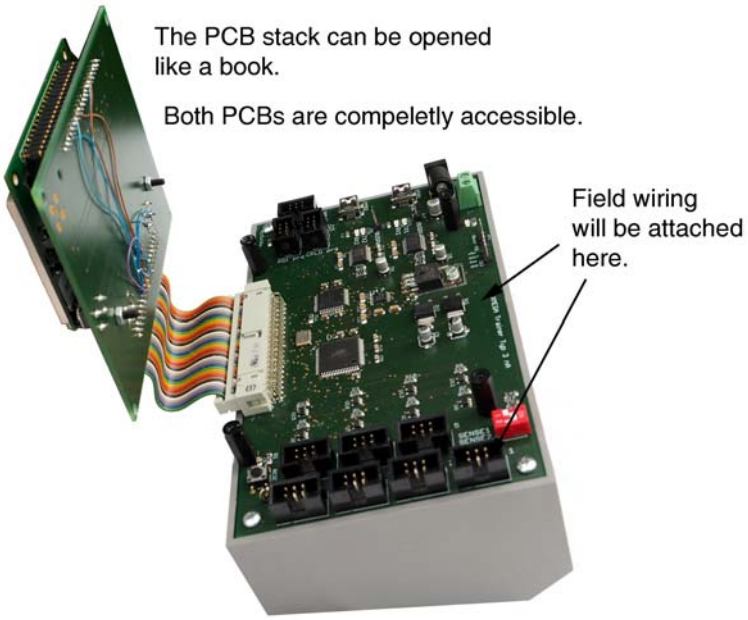
The type 3 n.A. is essentially an active hub for serial communication.

- Processor: Atmel Xmega64A3U.
- 5 V supply. 3.3 V signalization.
- Seven serial interfaces. 5-V signalization. One slave and six masters or no slave and seven masters.
- Two of the serial interfaces with selectable USB converter.
- One serial interface with selectable RS-232 conversion. D-sub connector to be attached externally.
- Two sense switches, programmable bi-color LED.
- Up to 30 I/O signals accessible via the general-purpose expansion connector.
- General-purpose expansion supports OLED display and Bluetooth on piggyback module.
- Jumperless configuration by software (supported by a Xilinx CoolRunner CPLD).

Two examples of configuration menues. The serial ports S4 to S7 can be configured. For example, serial port 4 (S4) can be connected to USB 2 or act as master 4, serial port 5 (S5) can be connected to the Bluetooth module (on piggyback) or act as master 5 and so on.

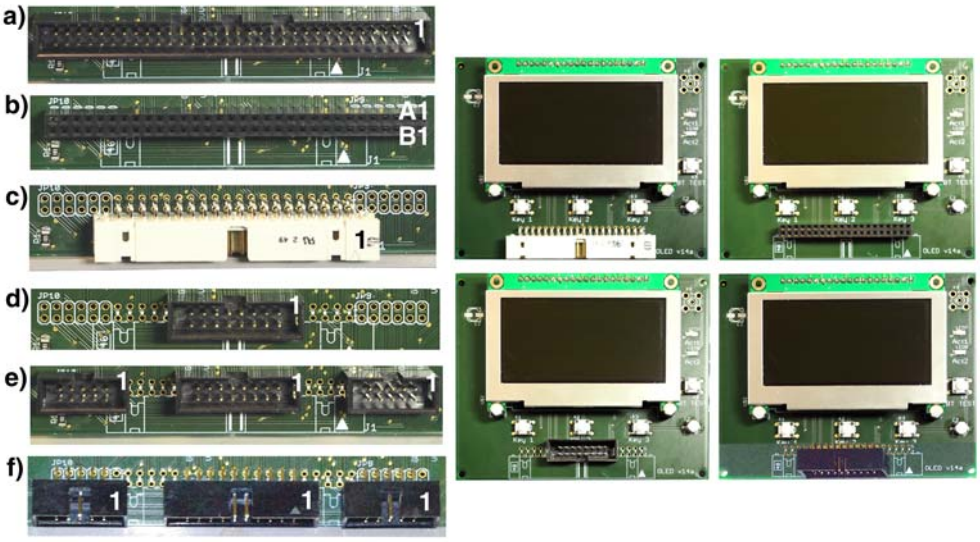


The basic idea behind the general-purpose expansion connector:



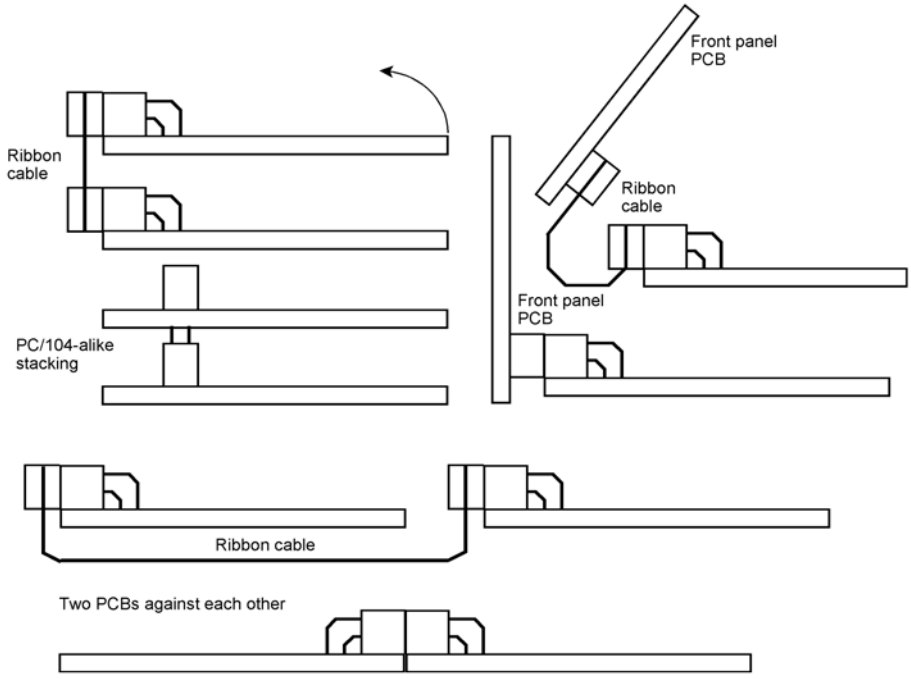
Different connector types can be inserted, provided they have two rows and a pin pitch of 100 mil.

Positions	I/O signals supported
64	Up to 48 I/O signals
40	Up to 30 I/O signals
20	Up to 14 I/O signals. Fits to piggyback module with OLED display, keys and Bluetooth
10	Up to 8 I/O signals (= one microcontroller I/O port)



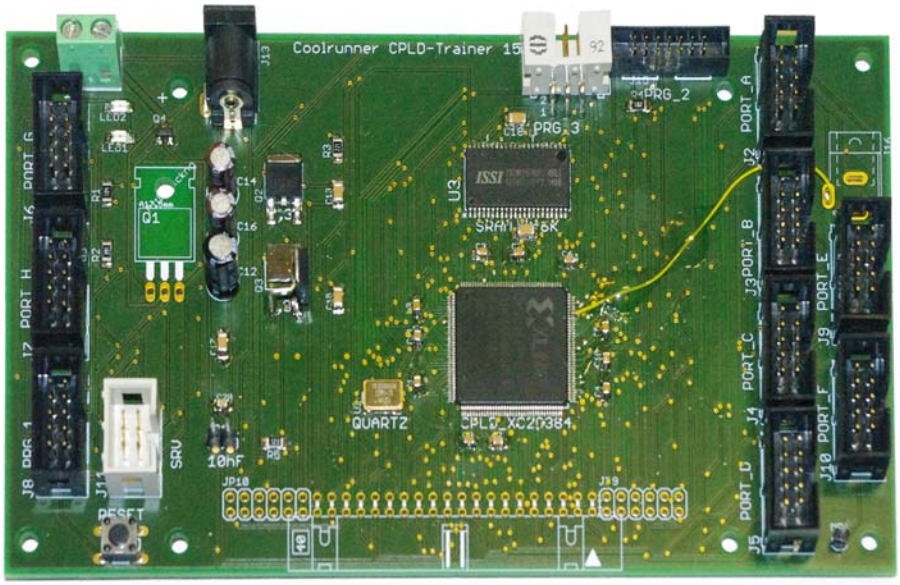
a) Straight box header; 64 positions
b) PC/104; 64 positions
c) Right angle box header, 40 positions
d) Straight box header; 20 positions
e) Three straight box headers; 10 – 20 – 10 positions
f) Three right angle box headers; 10–20–10 positions

Some variants of connecting and arranging PCBs:



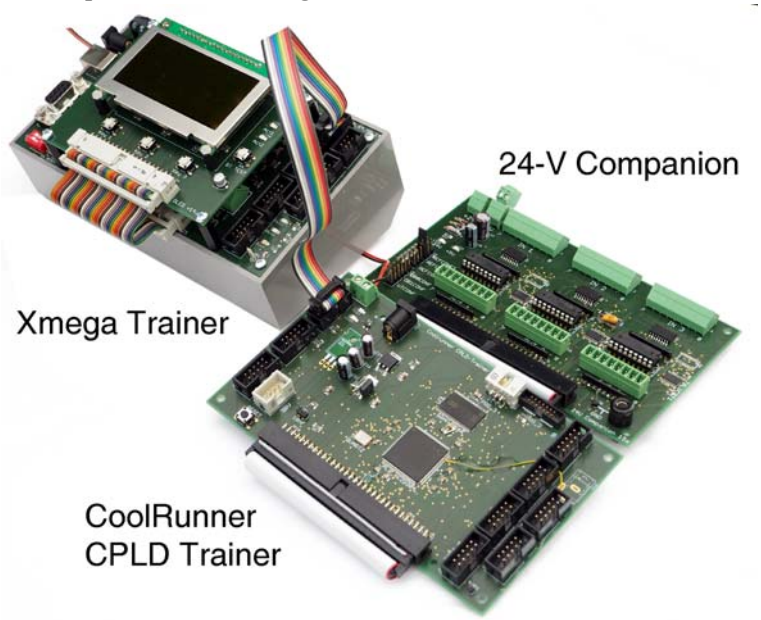
3. The CoolRunner CPLD Trainer 15a

CPLDs are the right components for small projects and for novices. CPLD development allows for concentrating at purely logical design; timing constraints, routing and so on has not to be considered. Turn-around times are short. Just enter the schematic or the Verilog or VHDL statements, let the system do the work, program the CPLD and see, whether it works or not ...



- CPLD: Xilinx CoolRunner XC2C384 TQ 144.
- 5 V supply. 3.3 V signalization. 1.8 V CPLD core voltage.
- Connectors for USB and legacy parallel port CPLD programmers.
- CPLD I/O signals constitute nine 8-bit-ports, which are routed to pin headers.
- Up to 48 CPLD I/O signals (six 8-bit ports) accessible via the general-purpose expansion connector.
- CPLD connected to SRAM 256k • 16. RAM capacity and word length are sufficient for small video controller, data logger, or microprogrammable sequencer projects and the like.

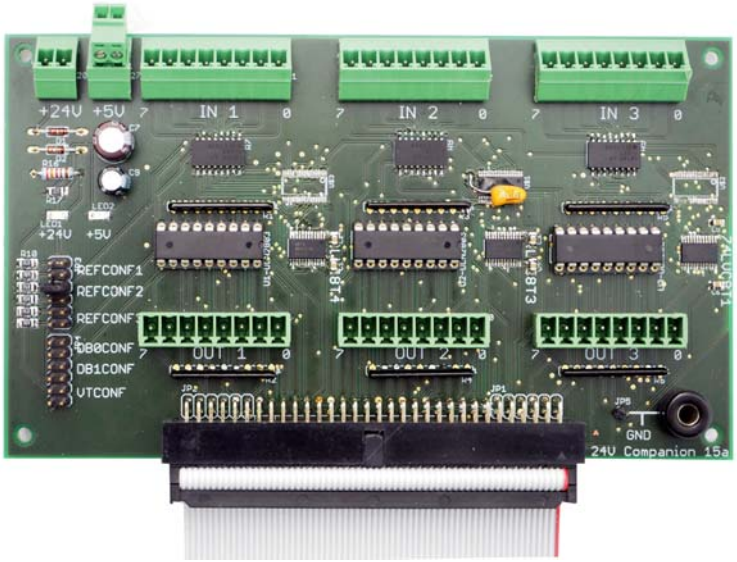
The CPLD trainer complements the Xmega trainers.



Three of the CPLD's 8-bit "ports" are thought for communication with the microcontroller (e.g., a 16-bit address and data port, accompanied by eight control and status signals). The appropriate headers are located at the left side of the PCB. The other six "ports" remain available to connect application-specific circuitry. These signals are routed to the headers at the right side and to the general-purpose expansion connector.

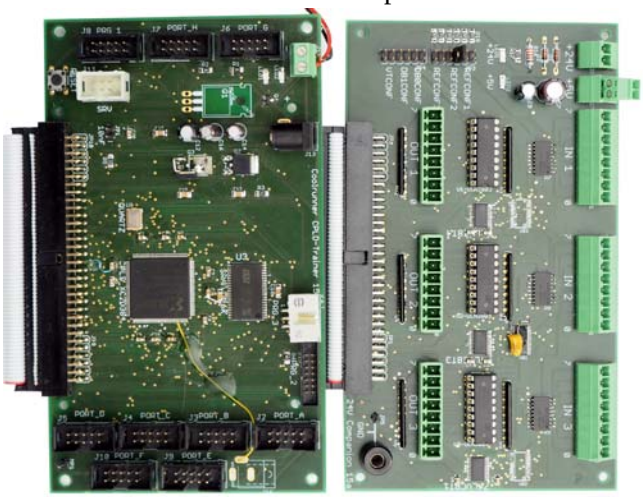
4. The 24-V Companion 15a

Level-conversion problems are quite demanding. The CPLD or FPGA has 1.8 V, the microcontroller 3.3 V. Industrial applications, however, require level translations to or from 24 V. To make matters worse, voltage levels in application environments may exceed 30 volts. Additionally, the circuitry must complain to stringent regulations (for example, IEC 61000-4). Component manufacturers are addressing these problems by offering appropriate converter ICs. To gain hands-on experience with respect to 24-V level conversion, an educational module has been developed. It is a companion board to be attached to Xmega trainers, all-in-one trainers and CoolRunner CPLD trainers.



- 24 (three 8-bit ports) 24-V inputs.
- 24 (three 8-bit ports) 24-V outputs.
- Input and output levels at the general-purpose expansion connector: 3.3 V.
- Outbound level conversion: 3 • ULN2803.
- Inbound level conversion: 3 • MAX31915 (from 24 V to 5 V) + 3 • 74LVC8T245 (from 5 V to 3.3 V).

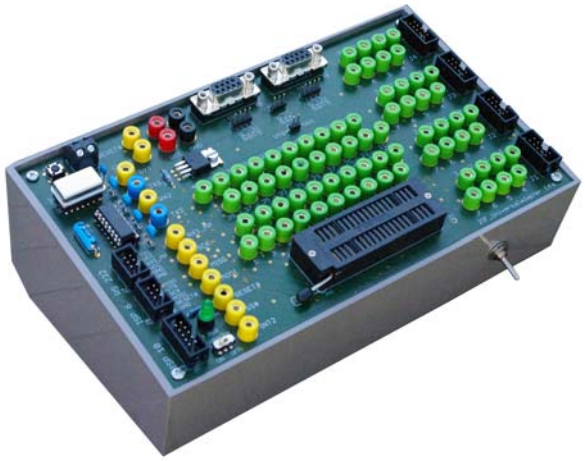
CoolRunner CPLD module connected to a 24-V companion module:



5. ZIF-Socket Platforms

Sometimes, wire is the best programming language. The ubiquitous white breadboards, however, show somewhat inconvenient, especially if the number of wires grows large. Contacts are not that reliable. The attempt to change only one connection in the wire entanglement will more than often result in inadvertently pulling out other wires, too.
Perhaps, it is not that waste to spend some money on banana jacks and test leads ...

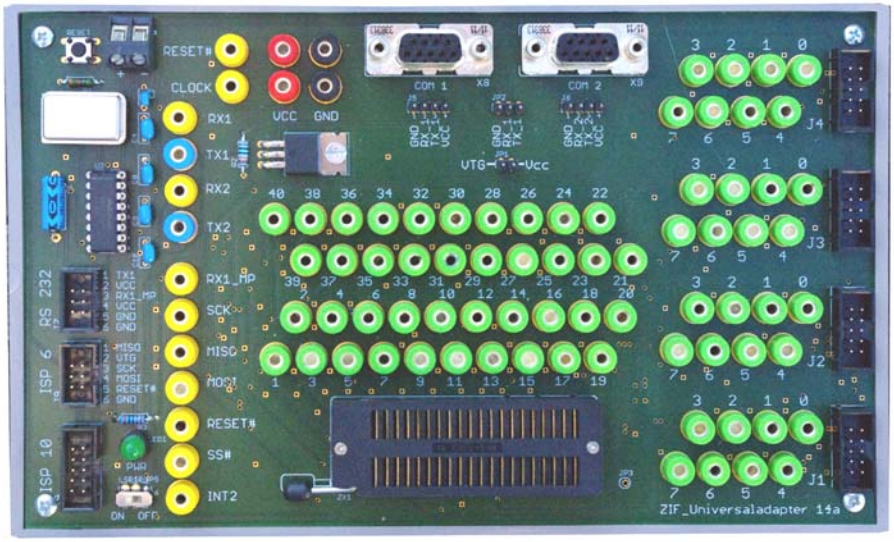
The general-purpose ZIF-socket platform 13:

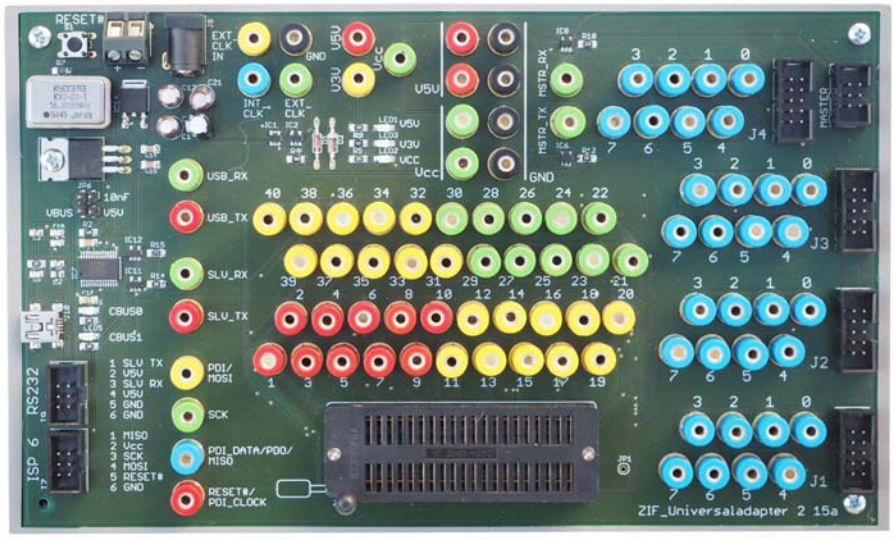


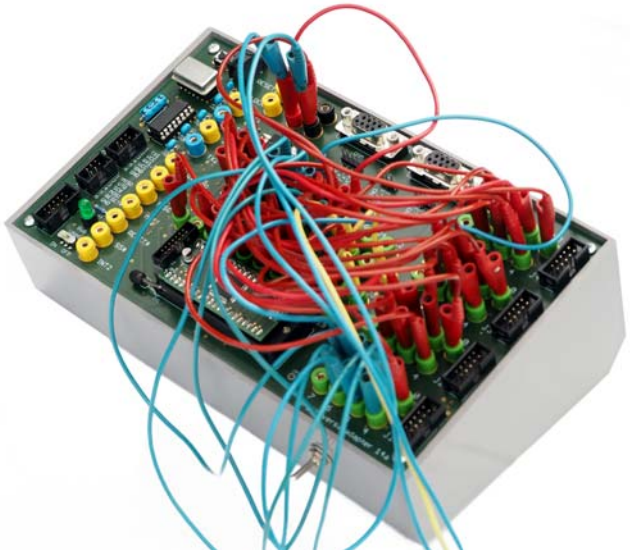
- On-board circuitry with 5-V supply.
- Antireversal protection.
- ZIF socket with 40 positions.
- All positions connected to 2-mm banana jacks.
- Four headers for 8-bit-ports.
- Two RS-232 interfaces.
- Crystal clock generator.
- Reset key.
- Headers for programmer attachment.

The general-purpose ZIF-socket platform 15:

- External 5-V supply with antireversal protection.
- On-board supply voltage selectable between 5 V and 3.3 V.
- ZIF socket with 40 positions.
- All positions connected to 2-mm banana jacks.
- Four headers for 8-bit-ports.
- Two serial interfaces with 5-V signalization (one slave and one master interface).
- Serial slave interface with USB converter.
- Crystal clock generator.
- Reset key.
- Header for industry standard Atmel AVR programmer attachment.

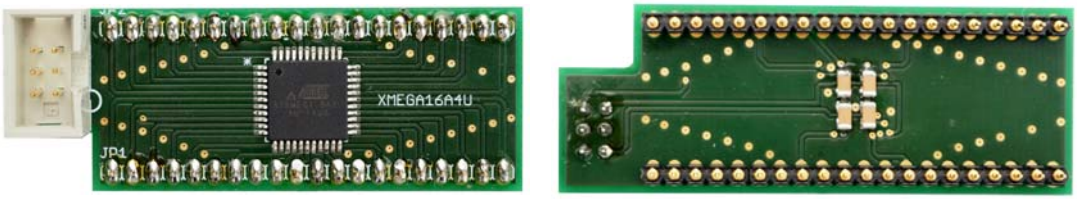






The ZIF-socket can accomodate each component, which fits between the contacts. SMD components, however, need special adapter boards.

Adapting an Atmel Xmega16A4U. The adapter board carries a header for programmer attachment.



Adapting a Xilinx XC2C64 CoolRunner CPLD. The board carries a header for programmer attachment and an LDO regulator delivering the CPLD's 1.8 V.

6. Stimulus and Responste the Most Basic Way

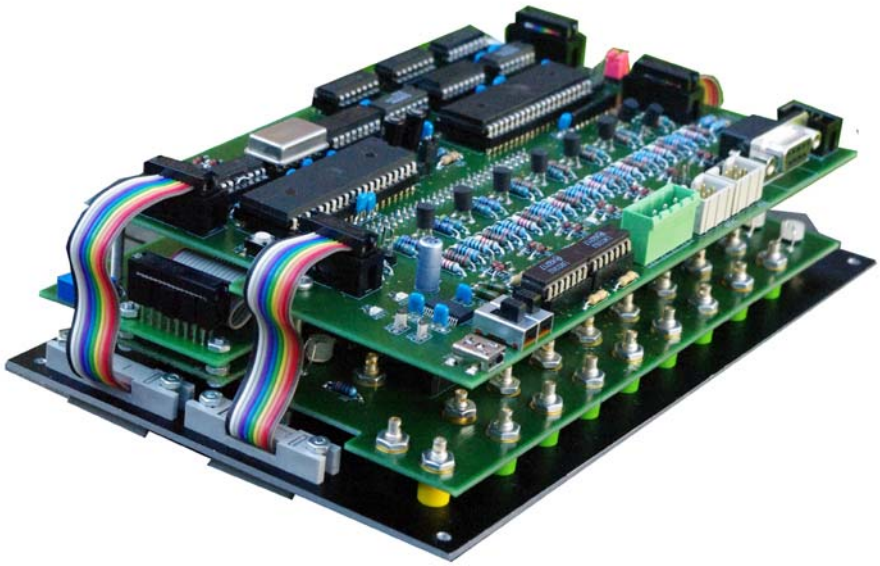
A toggle switch will deliver the most basic test stimulus, a LED or another visible indication will be the most basic means to observe the behaviour of the circuitry or device to be brought up, examined, or diagnosed. More often than not, such setups will be implemented cheaply, jerry-built, or improvised, for example, with DIL switches and LEDs plugged into white breadboards.

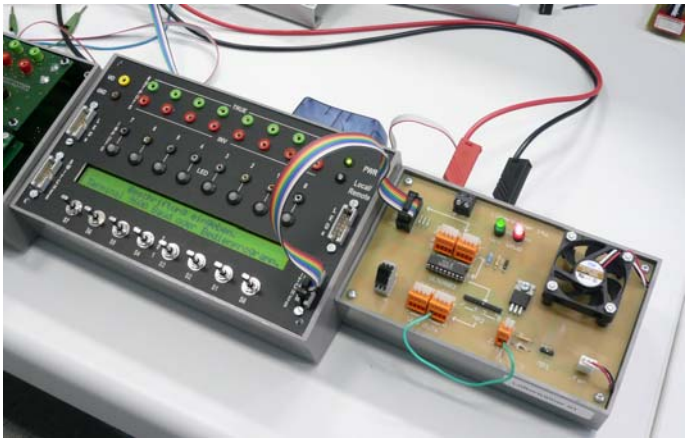
A legacy device – the toggle-switch unit 74 (shown only for comparison...):

The toggle-switch unit ("Kippschaltergeraet") 14:

- Eight inputs, eight outputs.
- Input and output headers on both sides.
- Input and output levels from less than 3.3 V to 24 V.
- Switches with momentary and latching contacts. Output signals are free of contact bounce.
- LCD dot-matrix display with two rows of 40 characters for labeling the inputs and outputs. No Post-it® notes needed anymore ...
- Serial interface with conversion to USB. Multiple units can be attached to a USB- or 5-V serial hub. Appriopriate software supports labeling and remote operation (when comfort is not that important, even a simple terminal program will do...).

With respect to mechanical design, the project was somewhat ambitious. All components (including switches and jacks) are on PCBs, which fit seamlessly together, connected only by ribbon cables.



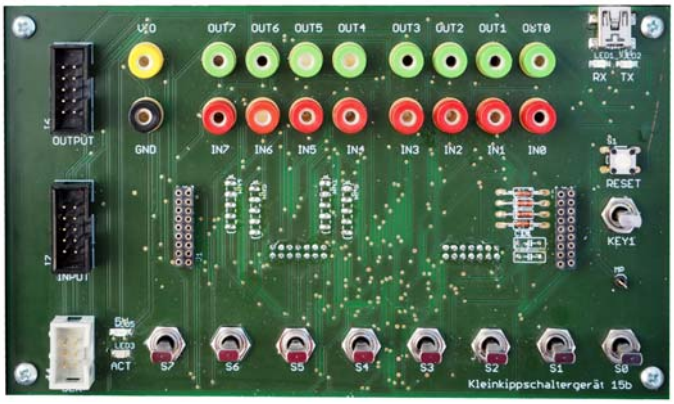


The development was a quite demanding task, especially as a student's assignment. However, the outcome was something nice, but heavy and overly expensive.

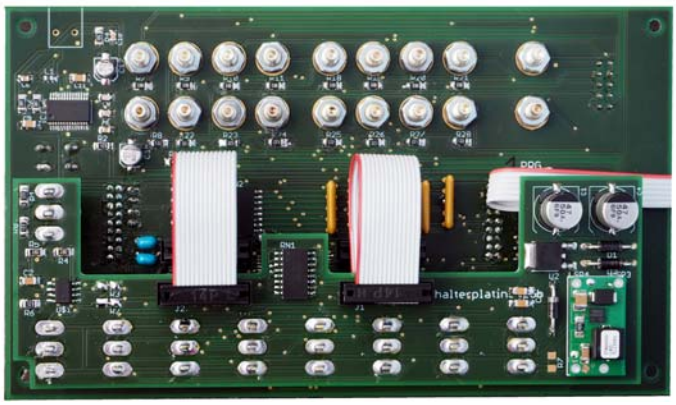
The simplified and cost-optimized toggle-switch unit ("Kippschalterkleingeraet") 15b:

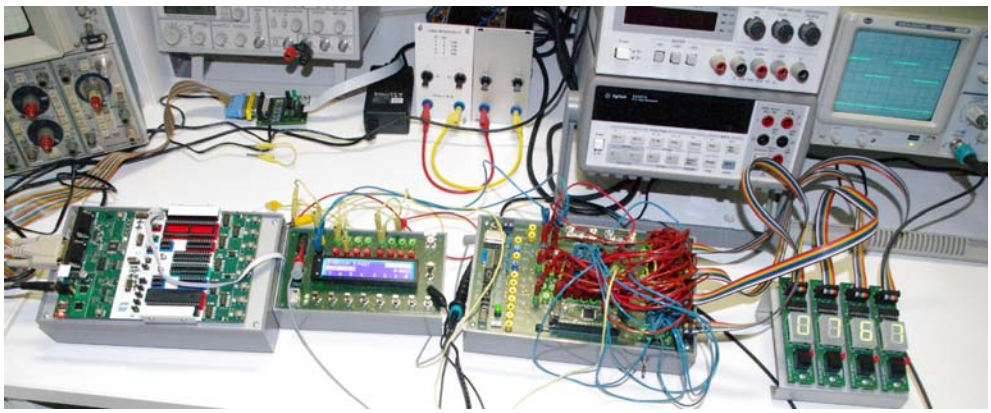
- Eight inputs, eight outputs.
- Input and output levels from 3.3 V to 5 V.
- Switches with momentary and latching contacts. Output signals are free of contact bounce.
- Graphical LCD display with 132 • 32 pixels, showing inputs, outputs and menues.
- Serial interface with 5-V signalization and conversion to USB. Multiple units can be attached to a USB- or 5-V serial hub.
- Small PCB size and simplicity of operation allow to do without a front panel. The PCB carries switches and jacks.

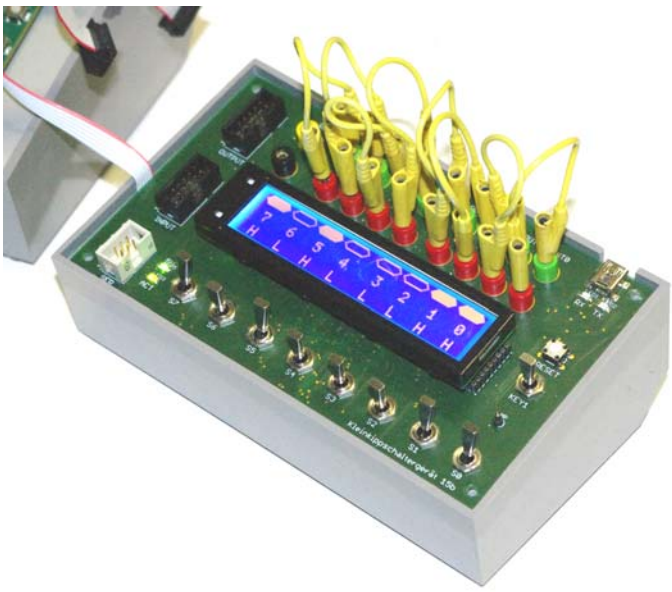
The main PCB without the LCD display:



A look from behind:





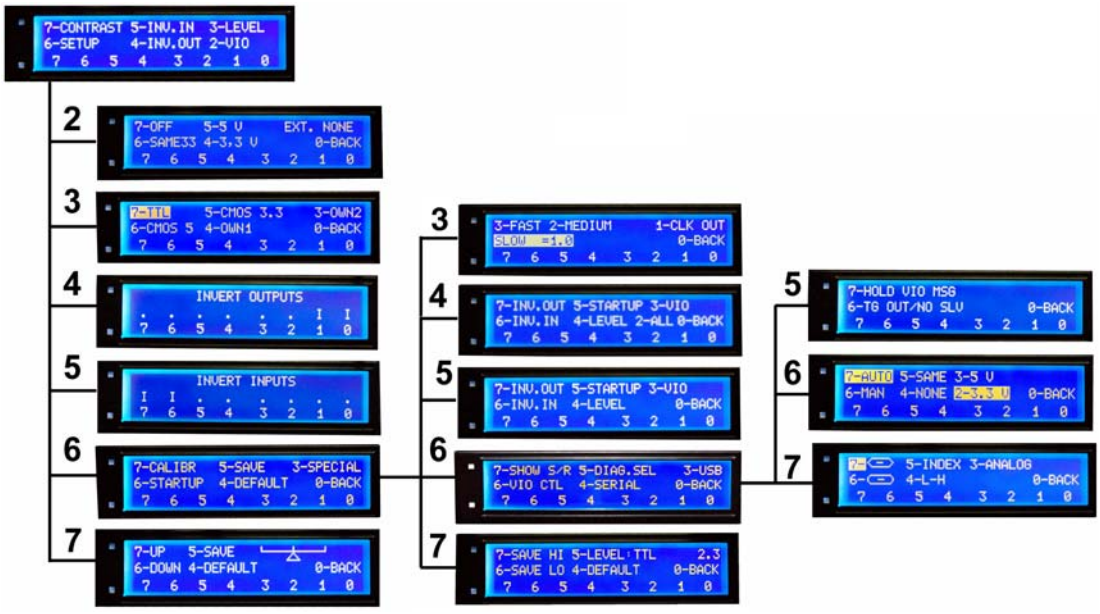


Different modes to show the input levels:

Showing analog voltages:

- 1st row: inputs.
- 2nd row: bit indices.
- 3rd row: outputs.
- An empty glyph indicates a low level.
- A white glyph indicates a high level.
- Symbols "–" índicate a level between Low and High.

The structure of the internal menues:



The toggle switches 7 to 0 are used to select menu items.