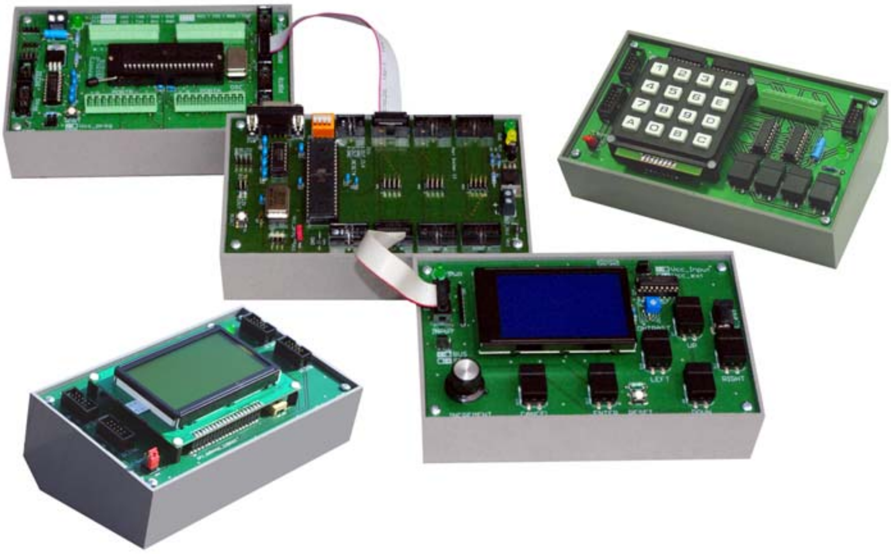
Projects Overview 2013

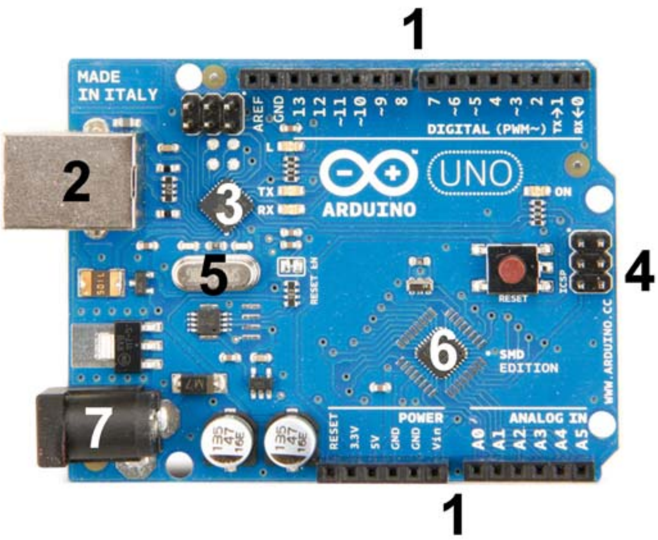
Release 1.1 (August 2013)

1. Microcontroller modules



The market seems to be saturated with small, inexpensive microcontroller boards, starter kits and the like. EBlocks, Arduino, Digilent, Eloxol, Velleman, and Parallax are just a few examples of trade marks and manufacturer names. Nevertheless, a closer look at such modules reveals some shortcomings and consequently, opportunities to make improvements. The modules are often intended for tinkering and experimenting only. They are no OEM modules. Typical examples are modules with switches, keys, displays and the like, which can only be operated on the desk, but cannot be mounted behind a front panel.

Let's begin with an in-depth examination of a well-known competitor:



1 – The connectors are cheap. Attachments have to be made wire by wire. The overall precision is low, so it could be difficult to stack modules one upon another.

2 – In an application environment, USB is not always necessary. It will be used only for programming and debugging.

3 – In this example, the USB attachment has been implemented the easiest way – by a USB to serial converter. To use the serial port (TX, RX) within the own application environment (for example, to implement a multiprocessor system) requires tinkering. The serial port operates only with logic levels, not with RS-232 levels.

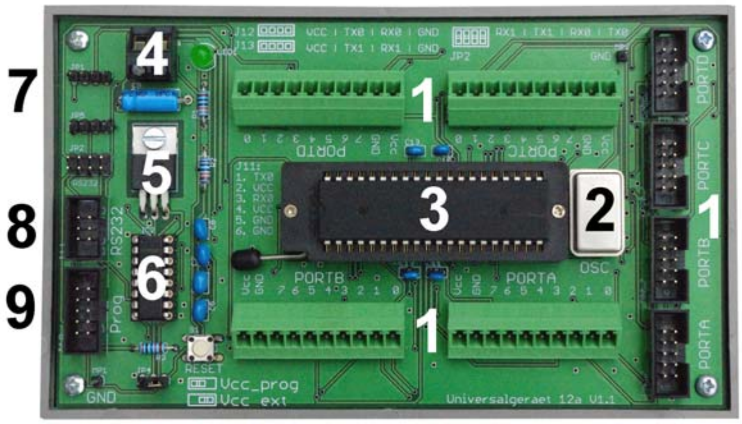
4 – In spite of the USB interface, it is still necessary to provide for connecting an SPI programmer (to restore the bootloader, if necessary).

5 – It is only a quartz, not a complete clock generator. However, some microcontrollers allow for the maximum clock frequency only if clocked by an external generator.

6 – SMD components are difficult to solder manually. A defective processor cannot be replaced easily.

7 – The power supply solution is inappropriate for an OEM application environment, in which all components need a common ground. In such applications, it is favorable to feed all modules with the same supply voltages delivered externally.

The modules are unsuitable for easily configuring multiprocessor systems. It would be possible, but not without tinkering. Now let's have a look at an alternate solution:



Engineering always means finding compromises. To overcome the drawbacks mentioned above, we will use components, which are more sturdy and will build somewhat larger. Our modules should be true OEM building blocks; it should be possible to use them in measuring and test equipment, industrial control units, and other appliances. For these advantages, we allow for a moderate increase in cost and dimensions.

1 – Sturdy I/O connectors. Various types can be inserted. Depending on the connectors, other modules can be attached via cables or stacked. Here, a more comfortable type of terminal strips is shown. The application wiring ends in pluggable screw terminals. Hence it can be removed with little effort.

2 – A complete clock generator can be inserted. Thus the microcontroller can be operated up to its maximum clock frequency.

3 – Enough space to allow for insertion of a 40-pin ZIF socket, thus enabling fastest processor swapping. It is possible to choose between different microcontroller types; ranging from greatest simplicity (for example, ATmega16) up to a maximum number of features and memory capacity (for example, ATmega1284).

4 – Power supply from outside. No voltage regulator on the board. Convenient power sources are a 5-V or 3,3-V power supply unit, a 3,5 V or 4.8-V battery, or the USB.

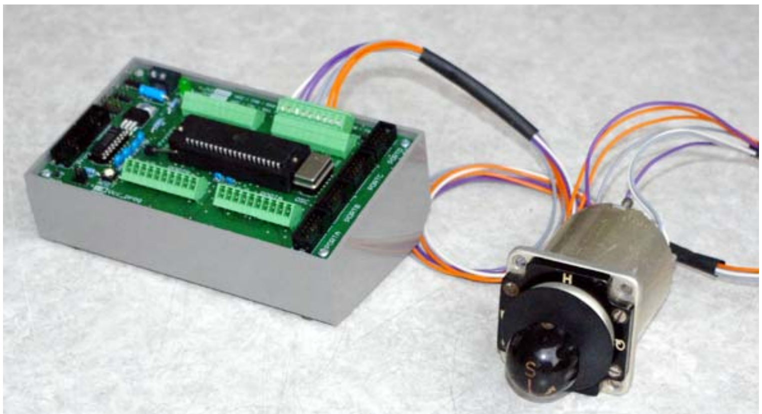
5 – Antireversal protection (the circuit invented by Bob Pease).

6 – MAX232. Depending on the microcontroller, up to 2 serial interfaces can be supported.

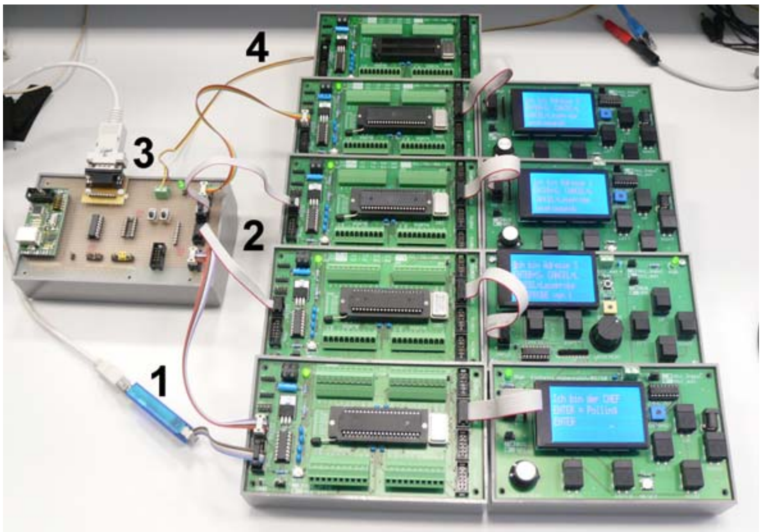
7 – Headers for RS-232 attachment.

8 – Header for multiprocessor coupling (logic level serial interface and power supply).

9 – SPI Header. Allows for attaching an SPI programmer or supplementing small boards containing Ethernet or USB adapters, serial memory and the like.

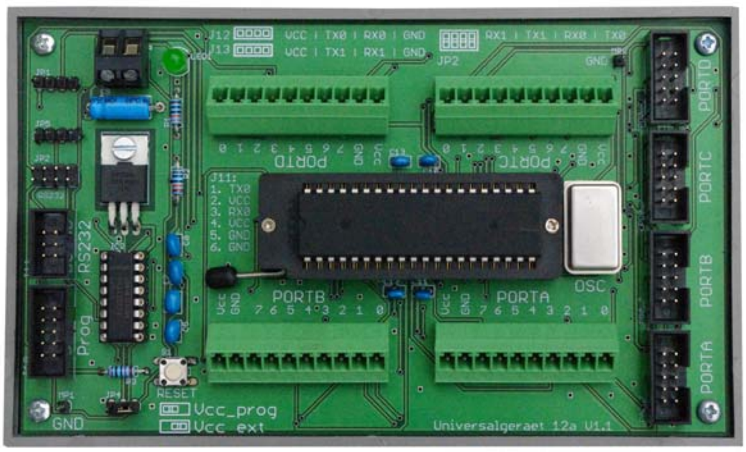


A historical joystick attached to the microcontroller module (try this with the competitor’s board shown above ...).

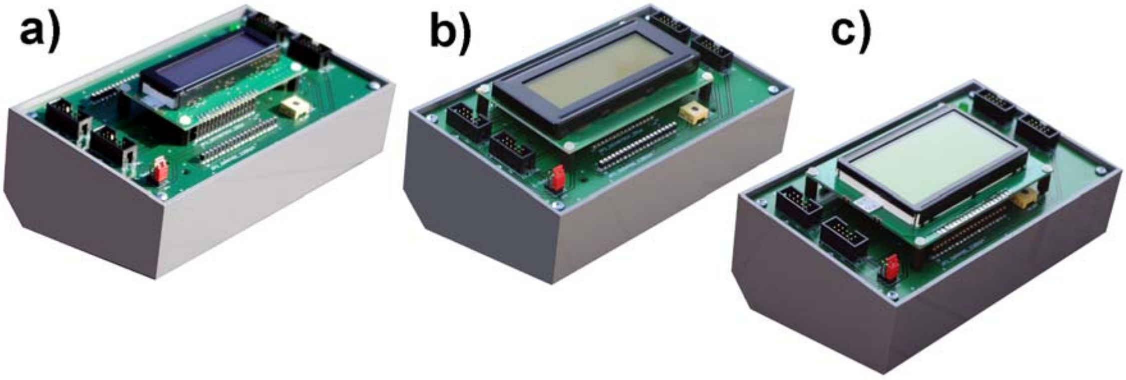


Microcontroller modules connected to a multiprocessor system. 1 – USB programmer; 2 – multiprocessor connections (only wire); 3 – passive hub (a prototype manufactured in the venerable wire wrap technology); 4 – power supply cable from a wall outlet adapter.

Here are some pictures of modules, which have been matured to PC boards.

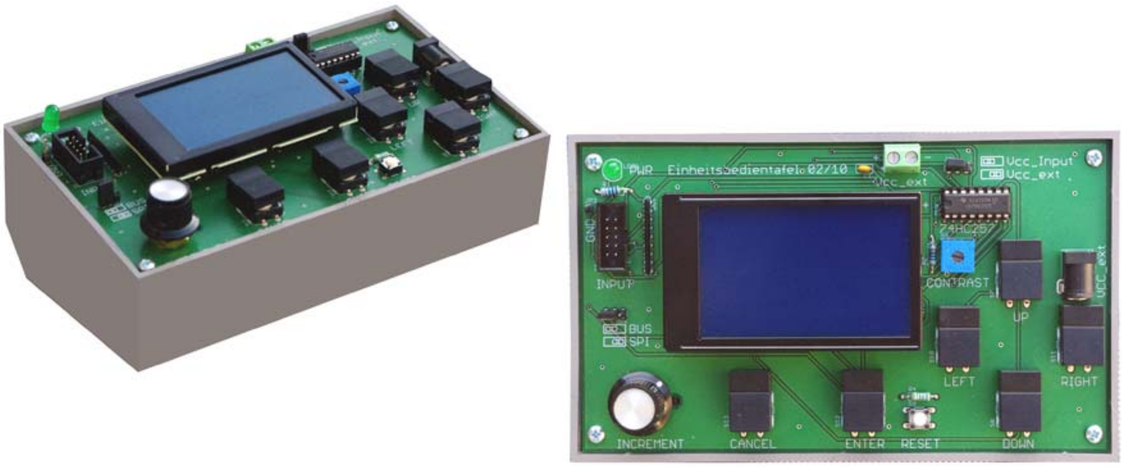


The general-purpose microcontroller module 12.

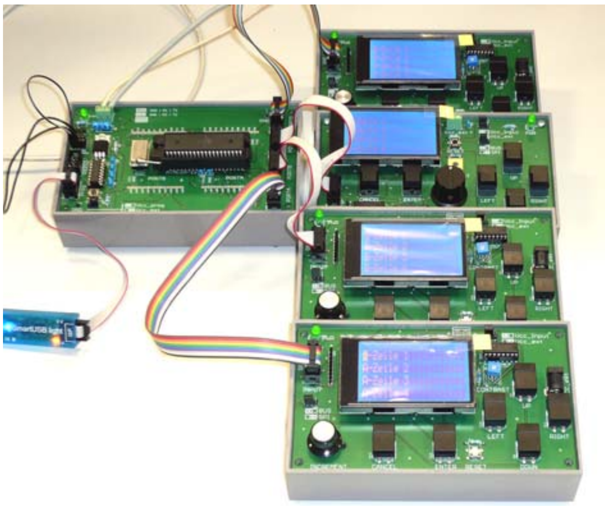


The LCD module 10. The PC board can accommodate three types of industry-standard LCD displays: a) dot matrix, 2 rows; b) dot matrix, 4 rows; c) graphical, 64 • 128 pixels. Up to three modules can be connected to two microntroller I/O ports in a daisy-chain fashion.

The keypad/input module 10b can accommodate keypads with 12 or 16 keys. Additionally, eight inputs from outside can be attached.

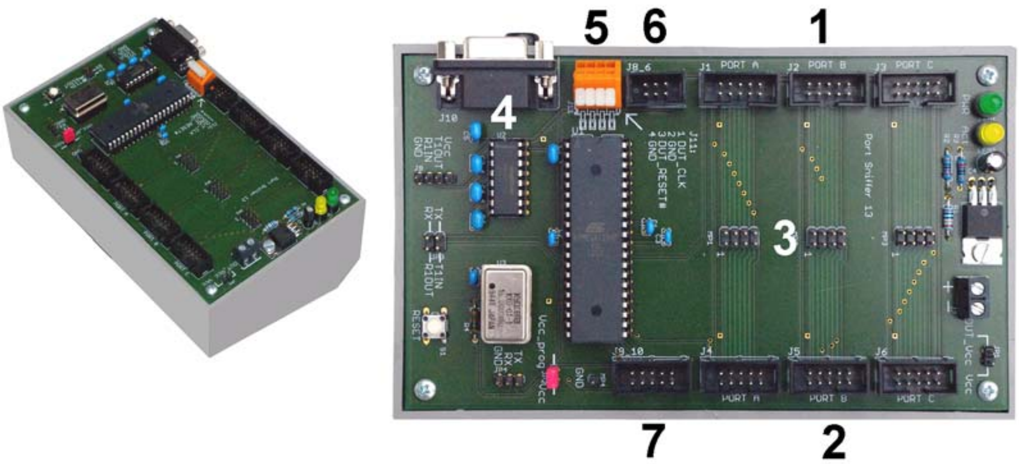


The general-purpose human interface module 02/10. It features a dot matrix display with four rows of 20 characters, 6 keys and an incremental encoder. It requires only one 8-bit-port.



A strong motivation for developing this module was the desire to demonstrate multitasking principles. Here one microcontroller module supports four human interface modules.

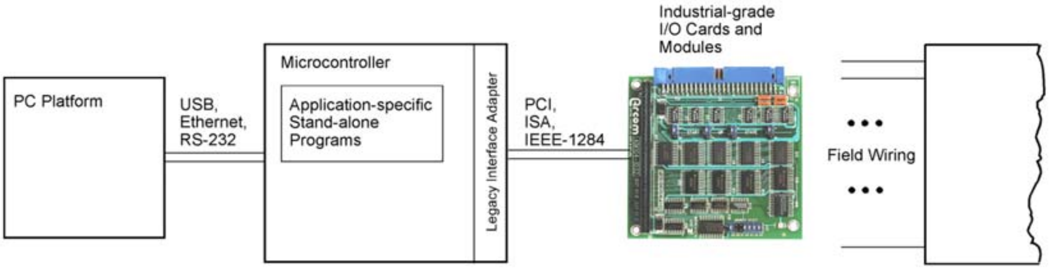
The modules with displays, key and the like can be mounted behind front panels, provided that appropriate connectors are inserted.



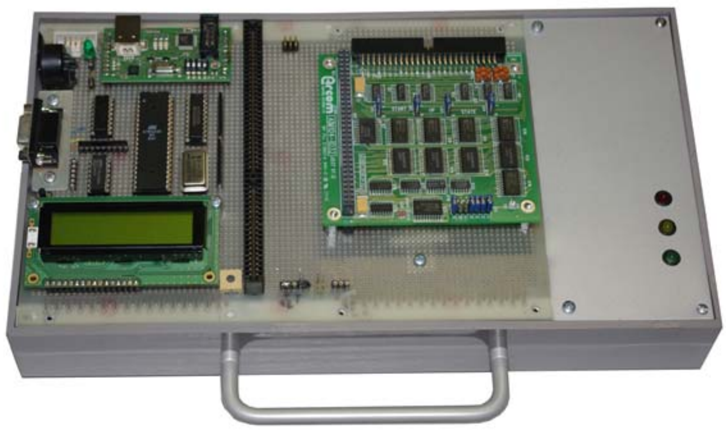
This microcontroller module is called the port sniffer. It is to be inserted in the connections between a microcontroller (or an FPGA, for example) and the attached peripherals. Its main purpose is logging and visualization. In other words, it is (connected to a personal computer) a very basic logic analyzer. 1 – inbound port signals; 2 – outbound port signals; 3 – test points; 4 – RS-232 interface; 5 – reset and clock signals for single-stepping the target system; 6 – header for multiprocessor coupling; 7 – header for SPI programming and system expansion.

2. Emulation of legacy interfaces

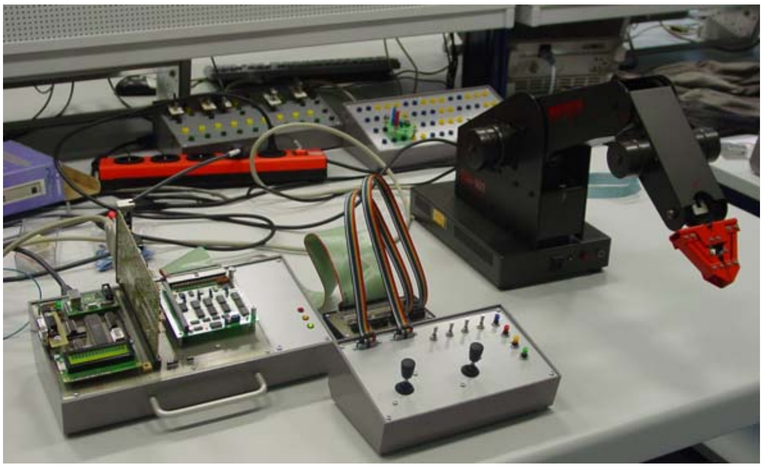
The idea behind is to emulate legacy interfaces of personal computers with comparatively simple means. These interfaces are well-described and well understood. Large numbers of add-on cards and peripherals are around. Some types are manufactured even today, above all PCI cards and PC/104 modules for industrial control and measurement applications. In many applications, bandwidth requirements are low. Hence it is possible to emulate the interfaces with inexpensive microcontrollers. (The next logical step would be an FPGA containing a microprogrammed control processor.) To develop and bring up such a device is a good exercise in engineering education, but it has its practical use, too. One can use up existing equipment. A microcontroller platform can be programmed freely, without regard to operating systems. Susceptible cards and modules can be operated within an environment, which consumes considerably less power and is free from the noise typical of personal computers. Some projects are still ideas; some are in the works; some have been matured to PC boards ready to be manufactured.



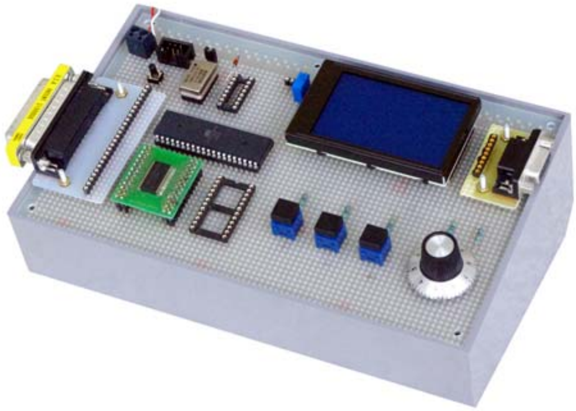
The basic concept. The personal computer is used essentially as operator console, file server, and development system. It will be attached only if necessary.



Emulation of the ISA bus by means of an Atmel AVR microcontroller. The emulation has been restricted to I/O functions, because in current applications, only modest I/O cards and PC/104 modules are to be supported. The emulation unit features a serial port, a piggyback USB module serving as serial-to-USB converter and SPI programmer, a dot-matrix LCD display, and a PS/2 port (the idea behind was to use cheap legacy keyboards as handy input devices).



The emulation unit controls an educational robot. The robot is attached via a legacy parallel port card, the operator’s console via a PC/104 module.

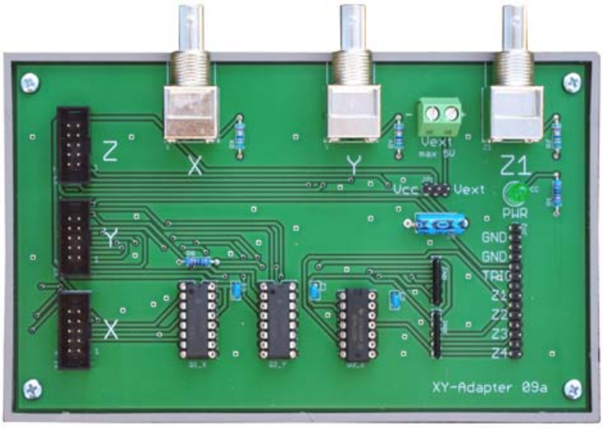


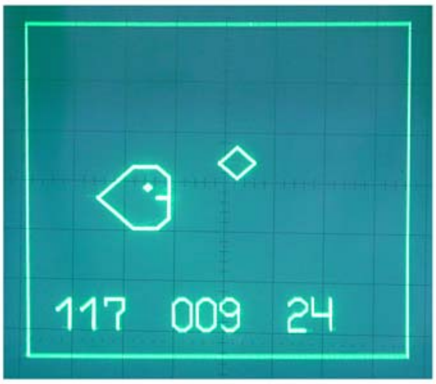
Emulation of the parallel port by means of an Atmel AVR microcontroller. Two different units are provided. One ist the host; the other emulates a peripheral device. Here the prototype of the peripheral device emulator is shown. The successors will be based on the microcontroller modules depicted above.

The PCI standard requires devices to be operational even with a bus clock of zero Hz. In other words, all PCI cards and modules must be able to be operated statically. Hence an AVR will be sufficient to control slow, step-by-step PCI bus cycles. It should be enough speed for relay cards and the like...

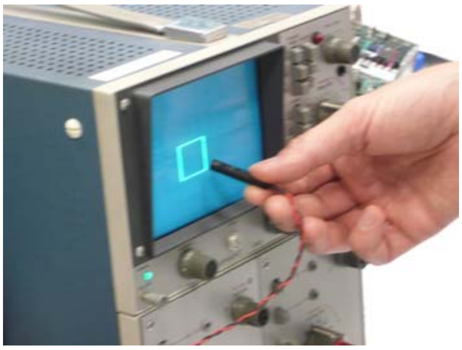
3. Educational and fun projects

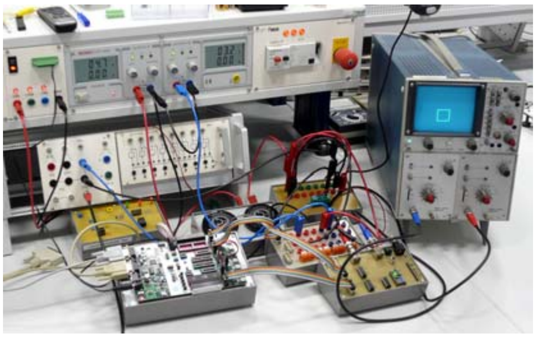
XY presentations
A PC board with two digital to analog converters (the so-called XY adapter 09a) allows to draw pictures on the screen of an oscilloscope. This device has been the platform for some fun projects and student exercises.



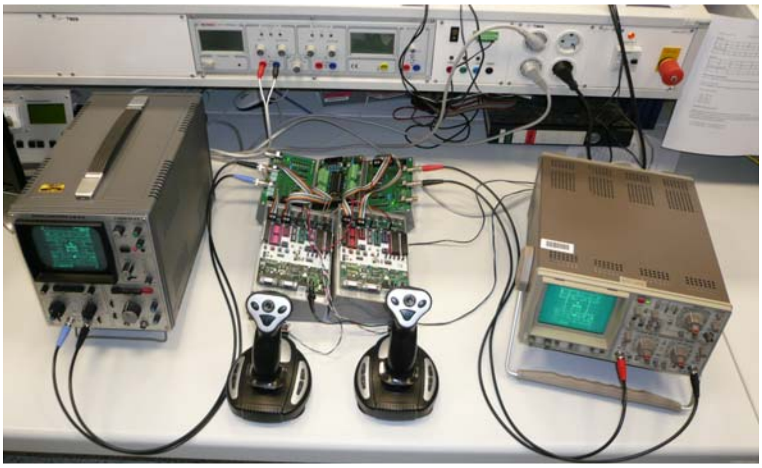


One Atmel AVR can support four different images on oscillsocope screens.





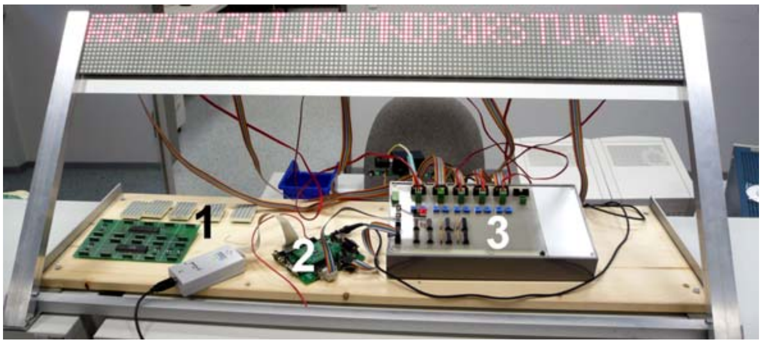
Even the venerable light pen technology can be demonstrated. The square on the screen follows the movement of the phototransistor in the little black tube.



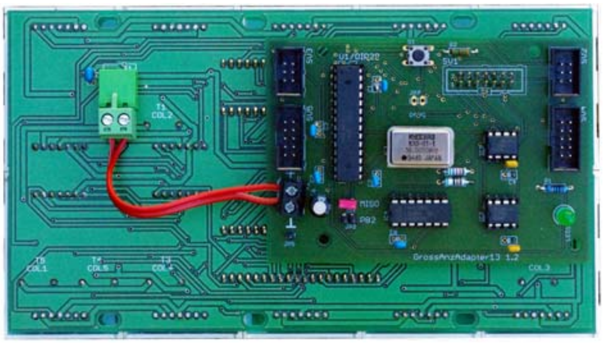
Ambitious students have implemented the venerable Pacman game on a system built with three microcontrollers.

Large-scale graphical LED displays

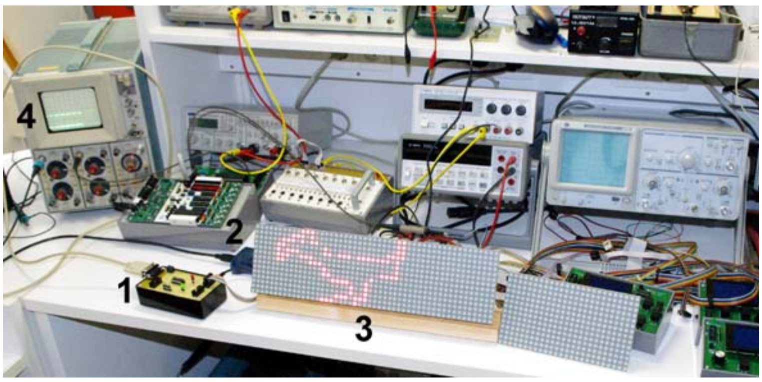
Developing LED-based graphic display solutions is a challenging task. Many LEDs are to be energized in a time-sliced manner. Despite heavy performance requirements, cost should be moderate. Even small mistakes in programming or hardware design will be clearly visible.



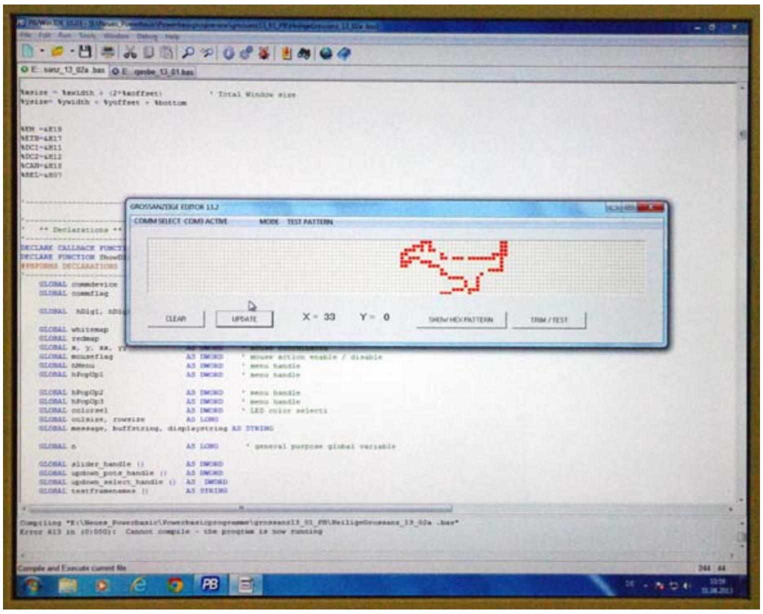
This display comprises 125 • 14 pixels. It consists of five modules. Each module contains 10 LED arrays of 5 • 7 pixels. 1 – a module without LEDs, 2 – ARM-based microcontroller platform; 3 – module adapter. In order to retain a reasonable multiplexing ratio (of 1:5), all modules are energized in parallel.



The ARM-based solution is straightforward, but wiring larger displays has shown to be a nightmare. Hence in 2013, each module has been equipped with its own microcontroller. All modules are connected serially in a daisy-chain configuration.



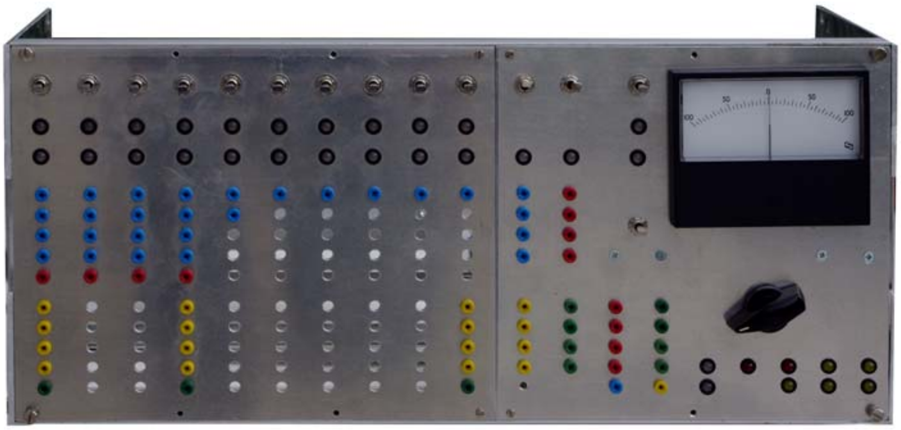
A glimpse into the workspace... 1 – adapter; 2 – USB programmer; 3 – LED modules; 4 - visualization of the serial communication.



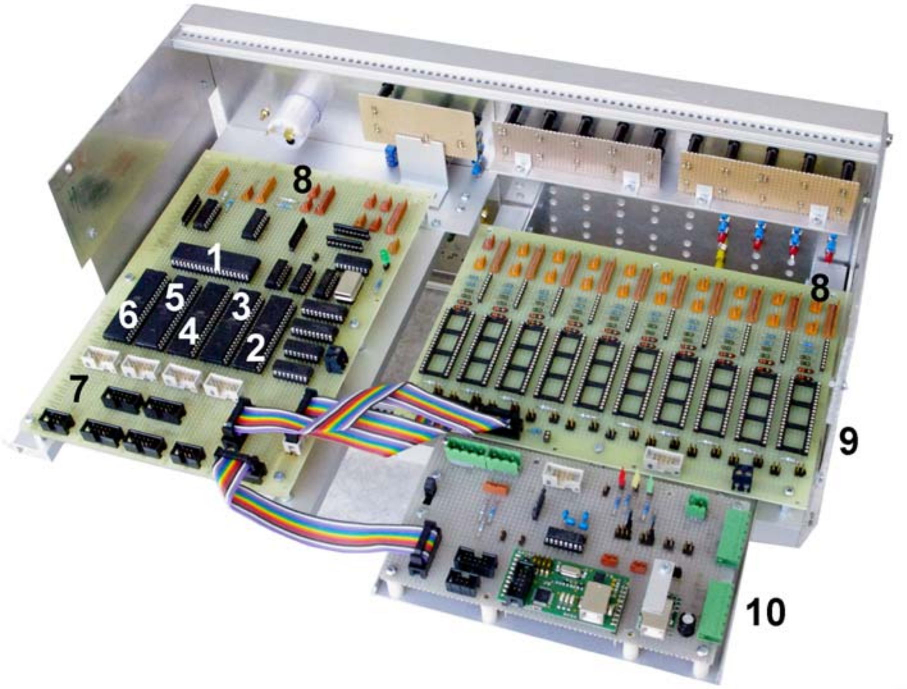
A program to generate impressive (more or less) displayable content.

The digital analog computer

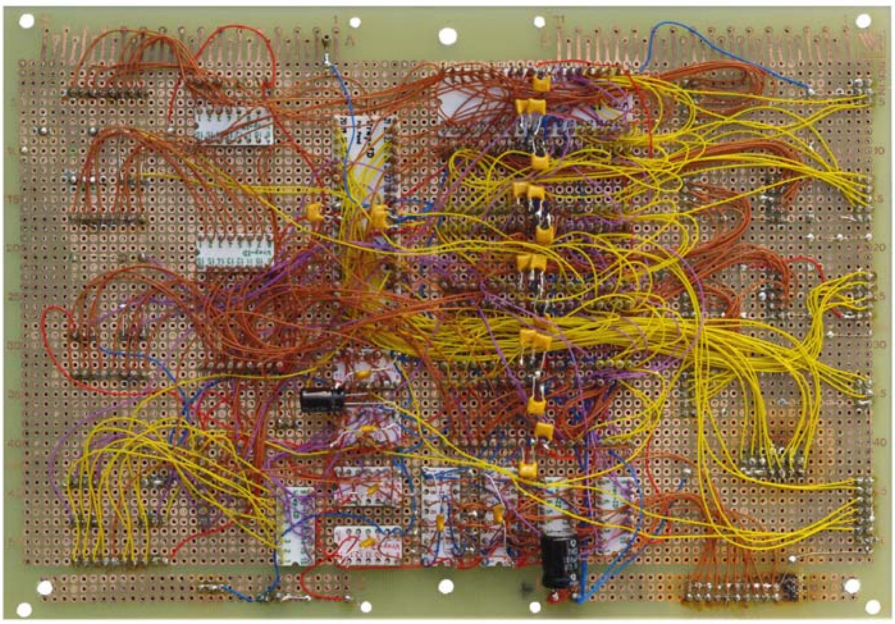
A computing device is to be built, which looks like a venerable analog computer, but is based completely on microcontrollers. 16 Atmel AVR microcontrollers emulate amplifiers, multipliers, function generators and the like. The device will be programmed by wire via a plug board. However, to select functions, set coefficients, display results and so on, a small computer is to be attached (despite being fond of old-fashioned technology, dials, multi-turn pots and the like would be too costly and would consume too much space). Each of the functional units has an attention key, whose actuation will cause the corresponding menu to appear on the screen. With appropriate microcontroller programs, the device could be made work, for example, as a digital or analog simulator or as a neural network.



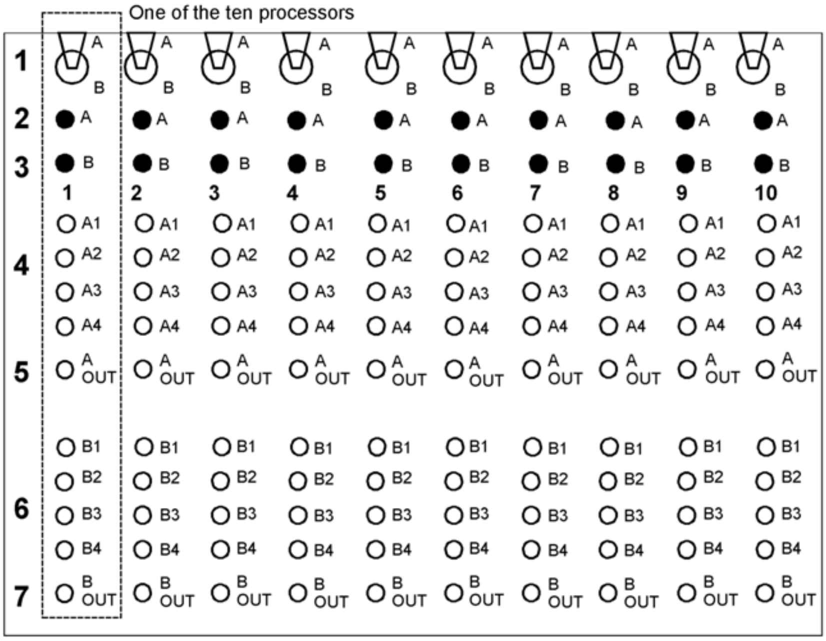
It is still in the works...



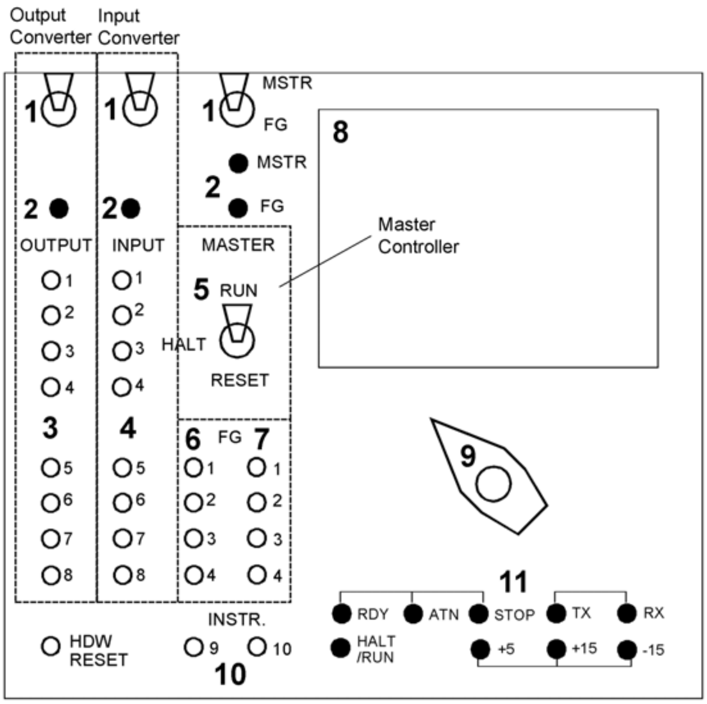
A closer look... 1 – master controller; 2 – main output converter; 3 – aux output converter; 4 – main input converter; 5 – aux input converter; 6 – function generator; 7 – headers for programming and connection with I/O circuitry; 8 – headers for connecting the front panel; 9 – 10 AVRs programmed as “computing amplifiers” (summers, multipliers, integrators and the like); 10 – central adapter (serial connections, programming, USB, power supply).



Sometimes, wire is the best programming language ...



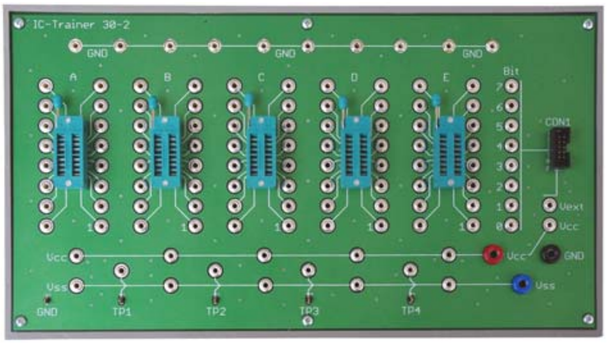
A closer look at the front panel of the "computing amplifiers". Each AVR executes two computational functions (A, B). 1 – attention key; 2 – function A state indicator; 3 – function B state indicator; 4 – function A inputs; 5– function A outputs; 6 – function B inputs; 7 – function B outputs.



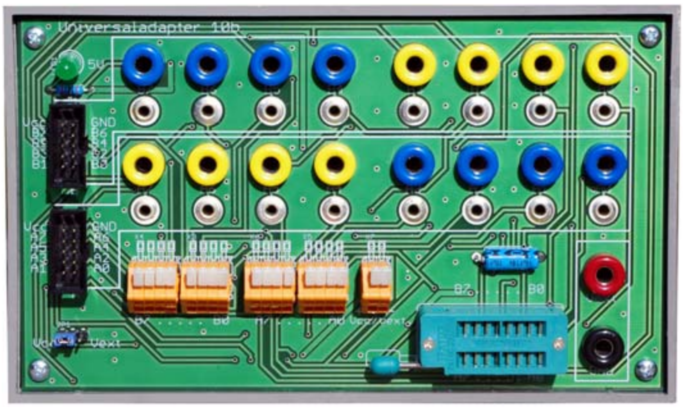
A closer look at the front panel of the converters and the master controller. 1 – attention keys; 2 – state indicators; 3 – output converter inputs; 4 – input converter outputs; 5 – operation mode selector switch; 6 – function generator inputs; 7 – function generator outputs; 8 – moving-coil meter; 9 – selector switch; 10 – additional inputs; 11 – interfaces and power state indicators.

Equipment for basic training in electronics

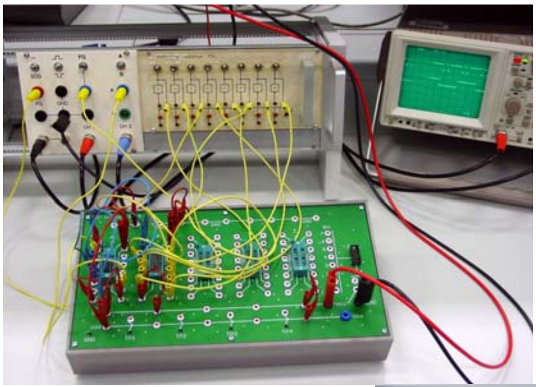
Everybody can run simulation software. However, it is only real hands-on experience, gained from basic, sturdy equipment, which makes the difference. The equipment shown below seems to be straightforward. Nevertheless, these humble design ideas have been grown out of long professional experience. Students and other newcomers have to be familiarized with basic skills. Today, most of the youthful smartphone users have no experience in dealing with tools, electronic components and the like (not to speak of true craftsmanship) ...

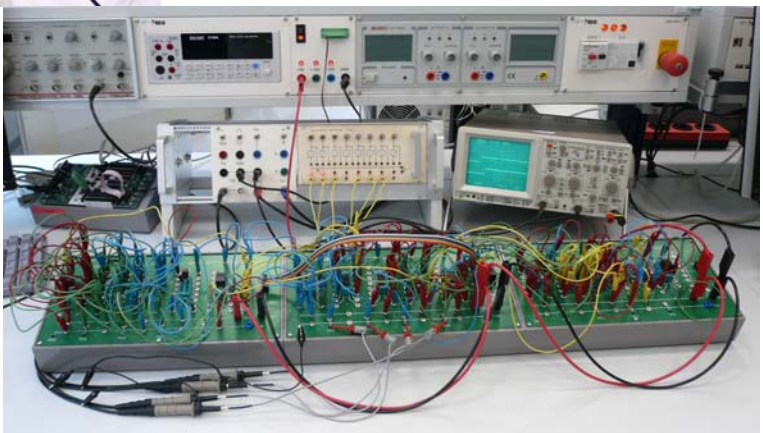


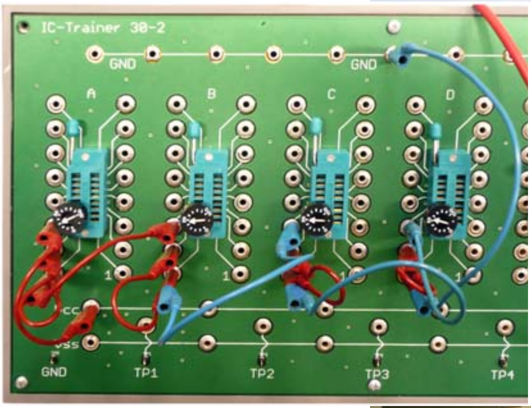
The IC trainer 10a provides five uncommitted ZIF sockets. They can accommodate integrated circuits, transistors, resistors, pots and the like, in other words, each component with pins or wires.

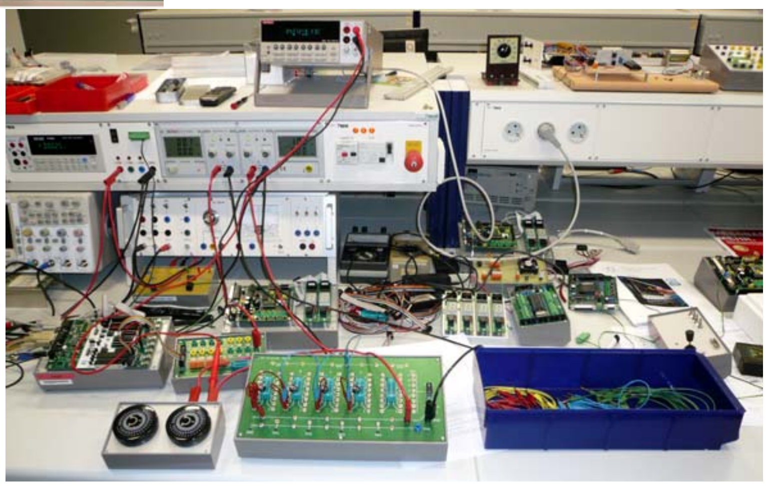


The universal adapter 10b. Two 8-bit-ports are connected to different banana jacks, sockets and terminal strips.



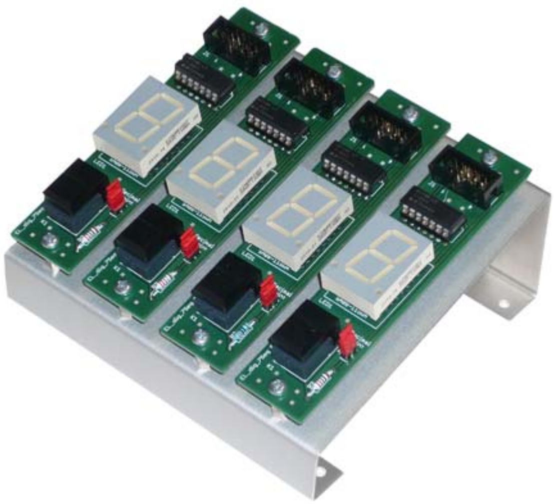






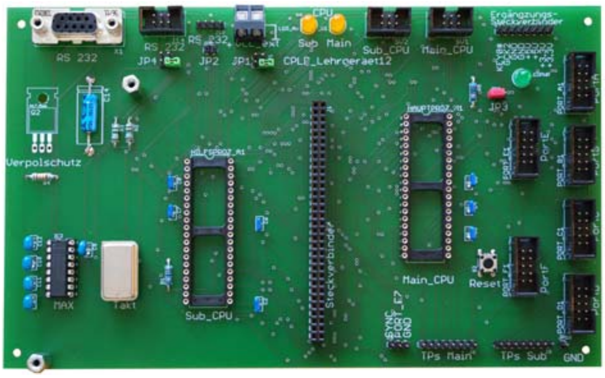
IC trainers and universal adapters in action ...

Combined with a microcontroller-based stimulus and display unit, the IC trainer becomes a basic digital trainer. It is operated by a personal computer or a tablet, respectively.

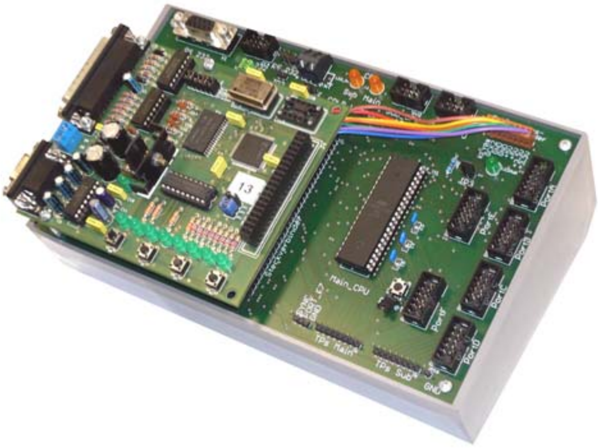


Small LED modules. Each of these strips is to be connected with one 8-bit-port.

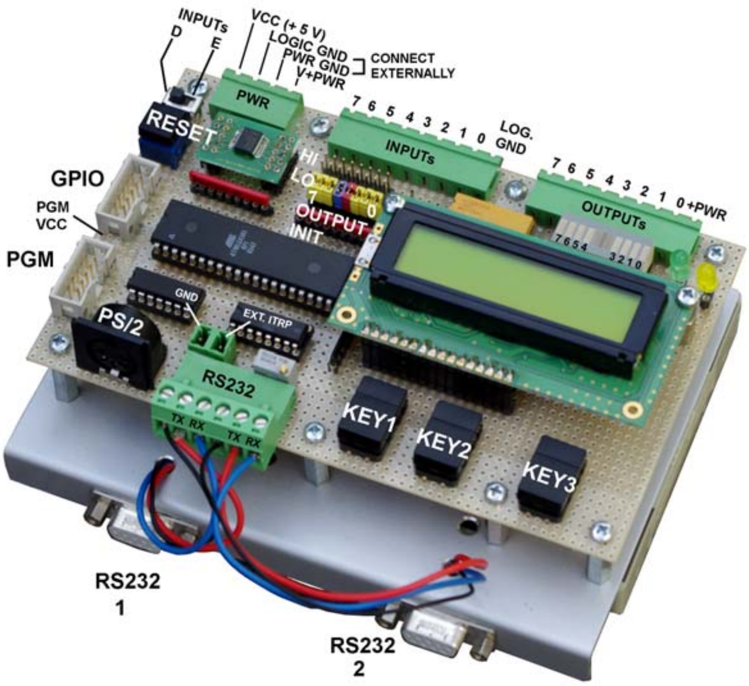
A CPLD module with parallel port programmer.



The CPLD trainer 12. CPLD modules are mounted in piggyback fashion. The trainer comprises two AVR microcontrollers, which deliver a test stimulus to CPLD inputs and scan the CPLD outputs. In other words, it is a basic, low cost test system.

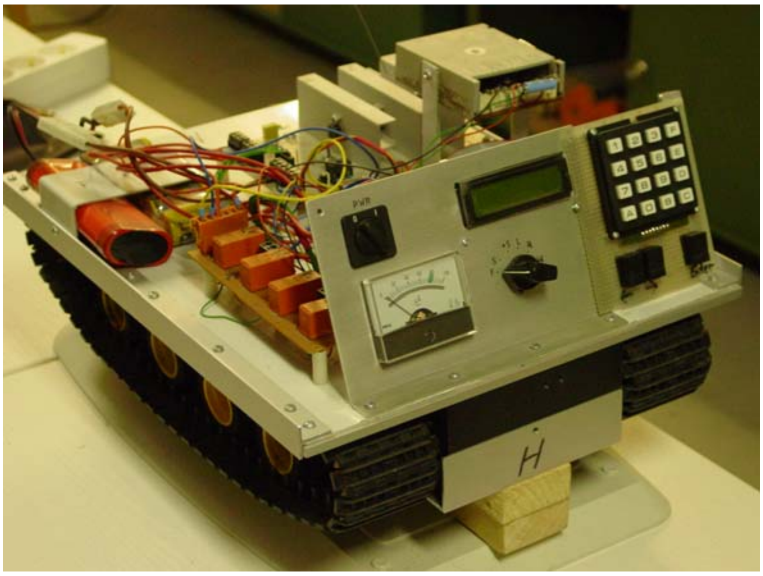


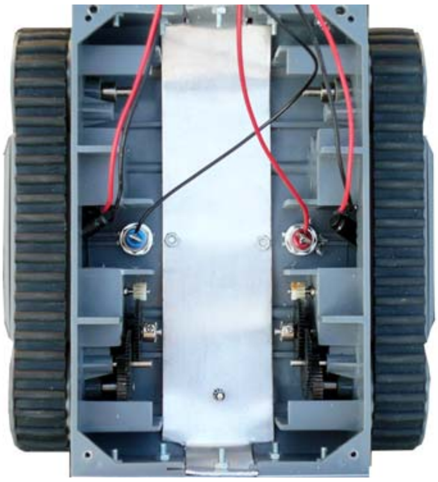
CPLD trainer 12 with a CPLD module.



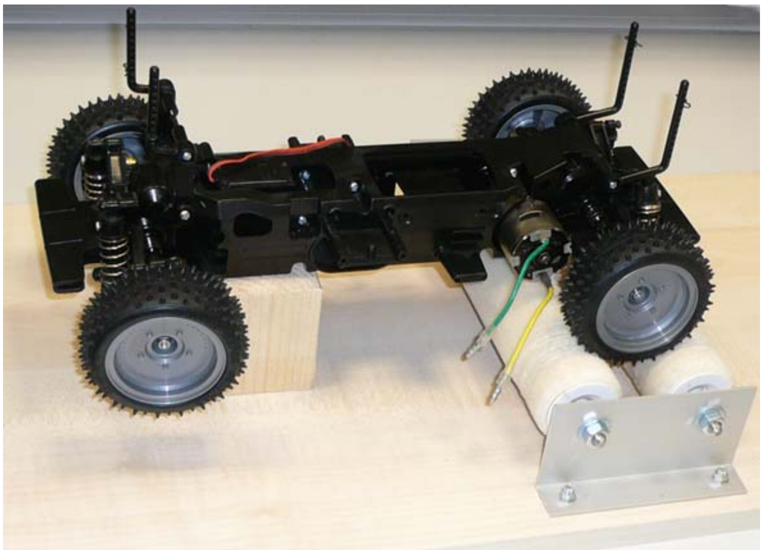
The programmable logic controller (PLC) 08 (to be mounted on a DIN rail). It is based on an AVR microcontroller.

Vehicles are popular themes for student’s exercises and theses:

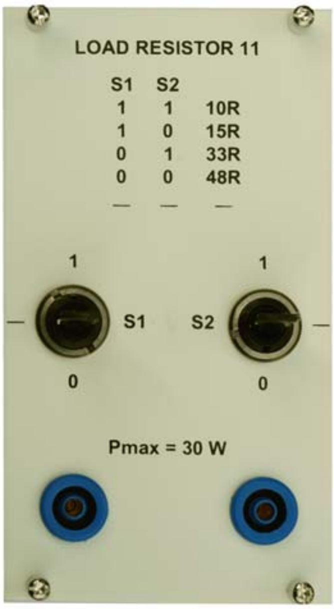


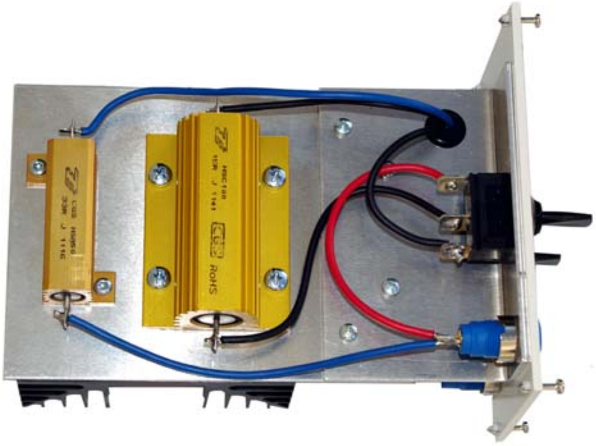


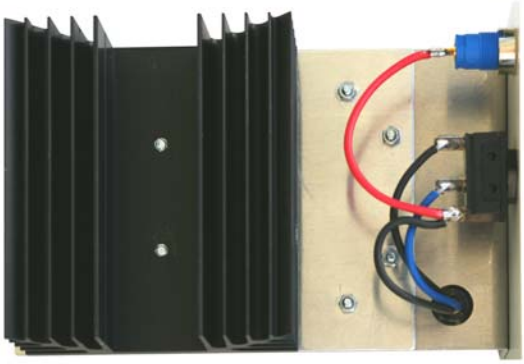
The ubiquitous track chassis (to build robots with) was not enough. So I have it modified...



Some of the test equipment for basic student training has been mounted in 19" racks. Requiring comparatively little cost and effort, this design principle yields sturdy functional units. Only the front panel, some components, and wire are necessary.

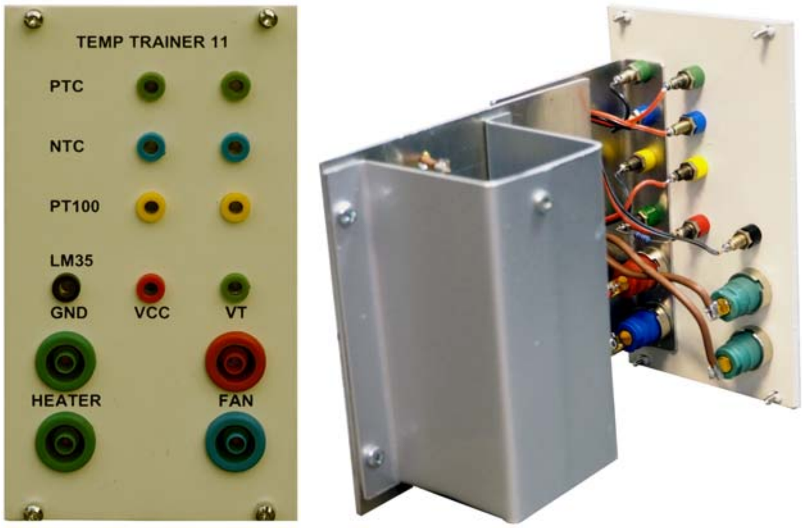






Electronic loads are expensive. Here is a true hi-tech alternative, based only on two switches and two resistors. Do not to forget the heat sink and thermal grease...

There are tasks of measuring and troubleshooting, where moving-coil meters are simply the superior instruments. A venerable wisdom, which contemporary students must learn by doing...



The temp trainer module contains a heater resistor, a fan, and different thermal sensors to experiment with.