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# Industrial Real-Time Control and Data Acquisition Systems: **ADwin**





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## **ADwin** – Real-Time Systems





**ADwin** systems are used by engineers and scientists around the world for real-time applications where deterministic, reliable timing is crucial.

They are user programmable data acquisition and control systems, which allow many different types of applications to run with precise real-time performance. This makes *ADwin* a universal platform for many different types of functions, applications, and industries:

- Intelligent data acquisition
- Complex trigger applications
- On-line analysis of data
- Open-loop control functions
- Closed-loop control functions
- Signal/Waveform generation
- Production and R&D test stands
- Production line automation systems
- Laboratory and mobile systems
- Fast machine control applications
- Material endurance tests
- Quality assurance tests
- Automotive & Aerospace Testing
- · Semiconductor and Component Testing
- Machine builders

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- Scientific & Industrial Research
- Nano-Science & Laser Industries



#### ADwin Real-Time Concept

**ADwin** systems are characterized by deterministic execution of intelligent data acquisition and control applications. This is achieved by utilizing a local CPU (DSP processor), which is the real-time heart of every **ADwin** system. The CPU is responsible for all real-time functions and guarantees a deterministic process execution, independent of the PC and its workload. **ADwin** systems work in close cooperation with the Windows-PC, but there is a clear job sharing: the job of the **ADwin** system is to execute fast and deterministic processes in real-time, while the jobs for the Windows-PC are standard functions such as a graphical user interfaces for applications, visualization of data, and data base accesses. **ADwin** systems add a real-time capability to a Windows PC; if the Windows PC crashes, the **ADwin** system will continue to run, maintaining the integrity of the application.

In addition to the local CPU, there is a large local memory for program code and measurement data, analog I/Os, digital I/Os, counters, different interfaces, expansions and options. The communication between the *ADwin* system and the PC is done via Ethernet or USB. Fieldbus interfaces allow the connection to PLCs, while a bootloader supports complete stand-alone operations of the *ADwin* system.

### What is ADwin Real-Time

**ADwin** applications always run in real-time; every sampled value can be evaluated in the same sampling step and a control function, or online analysis, can follow immediately after.

The best solution for fast real-time applications is to place a dedicated CPU close to the signals to have its own resources for the purpose of processing the data.

The **ADwin** CPU runs an optimized real-time multitasking operating system, and this combination provides exact, predictable process response times as short as 300 ns.

Applications with process cycle times from milliseconds down to microseconds range (from kHz to MHz) can run perfectly on *ADwin* in real-time.

## ADwin Software ADbasic, Driver, ADtools

INIT: a=12 b=3

#### The Real-Time Development Tool – ADbasic

**ADbasic** is the easy-to-use Real-Time development tool for deterministic and time-critical processes on the **ADwin** systems. Run an intelligent data acquisition function with online analysis or complex trigger conditions, use open- and closed-loop controllers, generate any kind of periodic or non-periodic waveform, **ADbasic** is always the key for the execution of many different real-time applications with deterministic operation.

**ADbasic** is an integrated environment under Windows with many online debugging features. Its easy-to-learn, standard command syntax has been expanded by a number of functions to access all inputs/outputs as well as functions for process control and communication with the PC.

Together with **ADbasic** comes the **ADwin** real-time operating system which has been optimized for the shortest possible response times down to 300 ns. It manages parallel processes which can be executed simultaneously in a multitasking mode, with different priorities and process cycle times.

**ADbasic** is source code compatible to previous versions; the same code can be executed on different **ADwin** systems with different CPUs. This means that by using **ADbasic**, **ADwin** gives you a great advantage for compatibility across product generations.

b=3
EVENT: x1=adc(1) x2=adc(2) x3=adc(3)
<pre>x4=adc(4) y=a*x1 + b*x2^2 dac(1,y)</pre>
z=func(x3,x4) dac(2,z)

### ADwin Driver

Drivers are available for a wide range of PC programs under the Windows or Linux operating systems. The software drivers provide functions for communication between PC, the **ADwin** system and **ADbasic** processes:

bi-directional data exchange of variables, arrays and data structures, FIFO data exchange, system booting, and process downloads, starting and stopping processes, monitoring and control of system variables and resources.

One of the key benefits in the *ADwin* <> PC communication is that it is possible to run fast deterministic real-time processes AND at the same time provide communication of data and parameters between the PC and the *ADwin* system. Both have no influence on each other; the communication does not disturb the deterministic timing of the real-time processes.





#### User Interface Tools – ADtools, ADlog

The graphical interface packages **ADtools** and **ADlog** provide easy-to-use visualization and control tools for **ADwin** systems. **ADtools** is a collection of indicators and controls, for communicating parameters to the **ADwin** system and for the visualization of measurement data. These tools are ideal for use during **ADbasic** software development and for quick labapplications. They offer direct access to all **ADwin** resources, as well as data storage to files and direct data transfer to Excel. **ADlog** is a simple data logging software program for **ADwin** systems. It allows analog, digital, counter, and CAN signals to be acquired, visualized and stored in different file formats. **ADtools** and **ADlog** are free of charge.

## **ADwin-Gold, ADwin-light-16** Compact Real-Time Designs

The ADwin-Gold, ADwin-Light-16 are two powerful real-time systems in a very compact design and for a reasonable price.

The *ADwin-Gold* is built in a robust metal enclosure and includes a fast local real-time CPU and memory, analog and digital inputs and outputs, as well as an Ethernet or USB interface for the communication with a PC. Optional configurations allow additional features such as counters, encoder interfaces, serial and CAN bus interfaces, and SSI interfaces. *ADwin-Gold* can be used in laboratories, on a DIN-rail in industrial machines, or in mobile and in-vehicle applications.

**ADwin-Light-16** offers capabilities similar to the **ADwin-Gold** system, but with a reduced number of channels. Based on one common design, there are three different versions: a PCI plug-in board, a Euro-size plug-in board, and an external system in a robust metal enclosure.

Because of their compact design, both systems are ideal for OEM applications.



## ADwin-Light-16

- 32-bit floating-point real-time DSP, 256 kB CPU RAM, 16 MB RAM
- 8 diff. analog inputs, 16-bit 10 µs ADC
- 2 analog outputs, 16 bits DAC
- 6/6 digital inputs/outputs, 1 trigger (event) input, TTL/CMOS; 32 digital inputs/outputs<sup>1</sup>
- Encoder interface<sup>1</sup>
- 1x32-bit encoder interface<sup>1</sup>; 2x32-bit counter<sup>1</sup>, event, period, duty cycle, up/down, encoder interface, PWM input
- CAN bus<sup>1</sup>, 1 channel, Automotive CAN, CANopen<sup>2</sup>
- Ethernet or USB interface to PC, Bootloader<sup>1</sup>

<sup>1</sup> Optional configurations, <sup>2</sup>via software



## ADwin-Gold

- 32-bit floating-point real-time DSP
- 256 kB CPU RAM, 16...64 MB DRAM
- 16 differential analog inputs via MUX and 2x16-bit 5 µs ADC and 2x14-bit 0.5 µs ADC
- 2...81 analog outputs, 16 bits DAC 16-bit
- 32 digital inputs/outputs, TTL/CMOS
- Trigger (event) input, TTL/CMOS
- Counter<sup>1</sup>, 4x32-bit, event, period, duty cycle, up/down, encoder interface, PWM input
- SSI<sup>1</sup>, 4 channels
- RS-232<sup>1</sup>, RS-485<sup>1</sup>, 2 channels
- CAN bus<sup>1</sup>, Automotive CAN, CANopen<sup>2</sup>, 2 channels
- Ethernet or USB interface to PC
- Bootloader
- Compact metal enclosure
- DIN rail mounting kit
- <sup>1</sup> Optional configurations, <sup>2</sup>via software



## **ADwin-Pro** Modular Real-Time Design



**ADwin-Pro** is the modular, scalable, expandable, intelligent real-time system for fast data acquisition and control applications in industrial and scientific environments. The modular design of the **ADwin-Pro** offers flexible, adaptable solutions for all kind of applications, with signal counts from a single channel up to several hundred. A wide range of I/O modules, chassis, microprocessors and memory options allow customization of the system for universal use, especially in industrial applications. The system runs via Ethernet in conjunction with a Windows PC, via a Fieldbus interface with a PLC, or as stand-alone unit with a bootloader. **ADwin-Pro** offers a modular, flexible design with various chassis configurations for many applications.



## ADwin-Pro

**ADwin-Pro** offers a wide variety of different real-time CPUs, analog and digital I/O modules, counters, interface modules, and many more.

- Real-time execution based on 32-bit floating-point DSP power and optimized operating system
- Modular, flexible design with several chassis styles
- Operation with a Windows PC, a PLC or with a bootloader standalone
- Different CPU modules and memory options
- Ethernet interface to PC
- Analog input and output modules
- Analog inputs with parallel ADCs, simultanious sampling for 4...120 channels without any phase shift
- Digital input and output modules
- · Comparator input modules with selectable thresholds
- Counter and PWM modules
- Encoder interface modules and SSI
- Filters, fixed or programmable types
- Amplifiers for thermocouple, RTD, 5B/8B modules
- Isolation amplifiers
- CAN bus, automotive CAN, CANopen, LIN, SPI
- Profibus and Interbus interfaces
- RS-232, RS-485 interfaces
- Customized VHDL code on digital or analog modules for OEM applications, e.g. non-standard interfaces

## Functions



#### Intelligent Data Acquisition, Online Analysis, Complex Triggering

**ADwin** systems allow the measurement of analog channels (multiplexed, parallel synchronized), digital channels, counters, CAN interfaces, and many more. In the easiest way, data is acquired for a period of time and stored.

But **ADwin's** great advantage are its real-time capabilities, this means that all measured data can online be evaluated with the local CPU, executed immediately after each sample in the same step.

**Online analysis** – Free programmable functions can be used, such as statistic operations, RMS, min/max, mean, integral, derivation, correlation, digital filters, FFT, signal analysis, etc.

**Intelligent or complex triggers** – The **ADwin** system allows mathematical operations, immediately executed in every sampling step. In the same step it is also possible to decide if any trigger condition has been reached or not, based on programmable logic-mathematical online evaluations. As a consequence, only those measurement data with information are acquired, the rest is rejected.

Data acquisition with online analysis or intelligent, complex trigger conditions is a strong **data reduction**; even with high sampling rates in the range of **kHz** up to **MHz** it is possible to acquire data for **hours**, **days** and **weeks**.





#### **Intelligent Signal Generation**

The **ADwin** system's real-time capabilities make it easy to create any kind of periodical or non-periodical waveforms. Digital or analog signals, single-channel or multi-channels can be calculated online by the **ADwin** system's CPU. Frequency, phase shift, amplitude, offset, and many other signal properties can be corrected in real time during any output step.

For high speed applications, multi-channel arbitrary waveform generators with large memory buffers are available. You can also combine different waveforms and overlay them to construct multi-frequency signals.

Generated signals can be time-controlled, phase-controlled, based on encoder inputs, or external trigger-controlled, so even flexible signal applications are possible.

Generating waveforms in an adaptive way is a function that allows to switch the signal output characteristic within a microsecond, within the same output step, based on signals at analog or digital inputs and online calculations.

The analog output modules have a parallel design; all channels can be updated simultaneously, without any phase shift between the channels.



### Fast Open- & Closed-Loop-Control

On all *ADwin* systems you can run fast digital **closed-loop controllers** such as **PID**, PI, cascade-, deadbeat-, adaptive-, and other controllers. *ADwin* systems are ideal for multichannel and high-speed controllers. Example: one *ADwin-Gold* can run 16xPID@15 kHz or 4xPID@60 kHz, or on the fastest *ADwin-Pro* 20xPID@100 kHz. The maximum speed for the calculation of one PID controller is 1 MHz! It is also possible to run on a single system different controller types with, if necessary, different control cycle times. Beside all control functions, other jobs such as data acquisition or signal generation can run on the same *ADwin* system at the same time.

**ADwin** offers also powerful solutions for **open-loop controllers.** Read any type of analog, digital, or counter inputs, calculate a free programmable online formula, or use a lookup table, and write new values to analog or digital outputs.

## Applications

#### **Control of Vibration Tests**

**ADwin** controls hydraulically or pneumatically operated vibration test stands and shaker tests in real-time. These test stands are single- or multi axial and stimulate the Device Under Test with defined profiles. Various sensors record the response, and a test analysis can be performed online.

A single **ADwin** system implements the following functions:

- PID-control of the cylinder position or cylinder force, including vibration-free mode switching
- A function generator
- Evaluation of the response, amplitude, phase shift
- Boundary value monitoring, including warnings
- General test stand control, pressure, temperature



Typical applications include for instance: sweep tests, endurance tests, resonance endurance tests with postregulation of the excitation frequency (resonance frequencies shift due to the heat of parts), artificial aging of modules, etc.

Examples of typically tested components:

- Automotive components
- Shock absorbers
- Motor bearings
- Brake pedal
- Exhaust pipes
- Chassis components
- Various prototypes
- Aerospace components, wings, etc.
- Material > steel, plastics, rocks, ...
- · Pipes and tubes

### Component Tests of Semiconductors, Relays, Sensors, E-motors, CAN Devices, Valves. ...

The **ADwin** systems are ideal for dynamic tests of various electrical, mechanical or semiconductor components. **ADwin** outputs stimulate the Device Under Test, inputs measure the response, and the CPU analyzes the response online. Due to the **ADwin**'s real-time capabilities for online evaluation, these tests can run for weeks and months with high sampling rates and without filling stacks of hard-discs.

Example: The wear and switching behavior of relays and switches is recorded for millions of switching cycles, with several test cycles per second. The *ADwin* system initializes each switching, measures with some MHz the analog response, calculates online the switching behavior for each cycle, and logs the results in a file.

Examples of typically tested components:

- Sensors
- CAN, LIN
- ECUs
- Relays, switches
- Connectors, contacts
- Semiconductors, boards
- Small electrical motors
- Hydraulic pumps, valves, and cylinders
- Magnetic valves, valves
- · Pipes and tubes

## Testing of Automotive Components

**ADwin** offers a wide range of applications and solutions in the field of the Automotive Industry. From single R&D test applications, endurance test stands, production line automation and test applications, up to end-of -line tests, **ADwin** is responsible for fast and deterministic control, automation and monitoring jobs.

#### Test stands for:

- Engines, gearbox, breaks
- CAN devices
- ECUs
- ABS, ESP, airbags
- · Shock absorbers, damper
- Steering wheels
- Injection valves
- Injection pumps

- Exhaust pipes
- Fuel cells
- LIN devices
- Flexray devices

#### Control of

- Dynamometer, servos
- Vibration tests

## Applications

#### Dynamic Contact Test – Detection of µ-Interruptions

**ADwin** has powerful counter and comparator functions for analog or digital signals. One strong application is the detection of  $\mu$ -interruptions at contacts from connectors, relays, circuit boards, cables, etc.

**ADwin** detects µ-interruptions by sampling the contact voltage, current or resistance at sampling speeds of 20 MHz and higher, by performing a software comparator function, calculating the size of an interruption, and storing the result in a statistical distribution for every sampling step. The test can run continuously for days or weeks, while at the same time allowing the user to access the statistical information of all µ-interruptions, as well as the raw data, without stopping the test or loosing any interruption.



### Applications for Electron Beam or Laser

Applications with electron beam or Laser are a perfect field for **ADwin**'s control capabilities. **ADwin** performs multi channel beam deflection, control of beam position, intensity, focus, etc. Typical scan rates are 0.5...20 µs per step, with a constant timing or a variable processcontrolled adaptive timing.

Typical **ADwin** jobs:

- Microscope applications > Laser microscopes, Scanning tunnel microscopes, electron microscopes, Atomic force microscopes (AFM), etc.
- Magneto optical traps
- Intelligent adoptive deflection
- Various research applications

### Test of Electronic Control Units – ECUs, Sensors, CAN Devices

**ADwin** offers various solutions for functional tests of ECUs (Airbag, ABS, ESP, ...), as well as for CAN devices, LIN devices, sensors, actuators, and other automotive, electronic components.

By using **ADwin**, all aspects of the ECU can be completely tested and all timings are accurate within the sub-microsecond range. The **ADwin** system tests the ECU by generating specific test signals, and stimulates the ECU via multiple analog and/or digital output channels. These test signals simulate 'real world' data, such as vehicle speed, engine temperature, acceleration, etc. In parallel to the stimulation, **ADwin** simultaneously monitors the outputs of the ECU and CAN/LIN messages, and analyses in real-time whether the ECU response corresponds to their specifications.

Similar procedures can be used to test a wide variety of automotive sensors, actuators or components.



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