Nano PLCs - small, but powerful
by Josef Ploch, Siemens

Building automation today is no longer confined to large business complexes, shopping centres or hotels, and extends much further than merely turning on lights or opening gates. Contemporary building automation affects almost every kind of structure imaginable, from skyscrapers to domestic homes where automation equipment is installed.

As soon the word automation is mentioned, it conjures up different perceptions for different people. But no matter which way it is viewed, automation has a continuous effect on every person's environment to the point that we can no longer live without it. It starts when we turn on a light in the morning, where behind the scenes, power is generated by fully automated power plants. Nearly everything we use during the day is produced in automated processes. When discussing automation, most people think of big factories like fully automated car production plants or large chemical processes. When thinking about buildings, generally people see the need for automation mostly in large complexes or expensive villas. In this article, though, the focus is on the lower end of the automation process. Turning off a printer in a vacant office or switching off a heater in a home when the window is open is the kind of building automation that can reduce energy consumption and lower overall costs. Over the last few years, very small and easy to use controllers have come to market with features constantly increasing. However, many engineers and architects do not realise the benefits offered by these controllers, such as excellent value for money and the low cost of implementation in a project. Last – but not least, the ease of use allows every installer or technician to use and service these products without extensive training or re-education.

Defining automation
So what exactly does "automation" mean? Definitions include:

• "The use of mechanical and/or electronic technology to accomplish a process with limited or no human involvement. The highest levels of automation incorporate self-regulation control." (Steve Martin)

• When the human performance of activities is replaced by mechanical or electronic processes.
• The replacement of manual operations by computerised methods

All of the above mention electronic technology as the main driver of automation. In the last 50 years, this technology has developed continuously and in the age of computers, the old programmable connection controllers (PCC) cabinets with relays, timers and counters have been replaced with special computers for factory and building automation - the programmable logic controllers (PLCs).

Classifying PLC systems
As PLC systems have many variations, it is important to classify them according to their features. The following common classification is used by most analysts.

As every company defines its products differently from their competitors, it seems best to use the classification that is used by the analysts. Nevertheless, there is no clear line between the classes. In addition, there are also soft PLCs and other automation controllers available not listed in this overview.

Nano PLCs, logic modules or smart relays
This controller class was first released in 1996 by Siemens as a replacement for relays, timers and counters. They called it LOGO!. It replaces auxiliary contacts, reduces wiring efforts and brings flexibility to the lowest level of automation as it is easily programmable using a software tool. Typically for this class of controller is the possibility to use the small display and the buttons on the basic module to create or change a programme without any PC on-site. However, the small display is much more important as a human-machine-interface (HMI). It can show operating instructions, process variables, error messages or service information without adding additional text displays or operator panels.

Nano PLCs or Logic Modules reduce the hurdles associated with changing from conventional control cabinets (PCC with relays, timers, counters, etc.) to PLC controlled systems that typically require well trained engineers and technicians and a high investment in programming infrastructure.

Common features for all brands of Nano PLCs are as follows:

• The basic modules have digital I/Os and some analogue inputs
• Most of them are expandable up to around 40 digital and 10 analogue I/Os
• With communication modules, they can be connected to larger systems and can be also used as intelligent remote I/O systems
• Unlike larger systems, Nano PLCs mostly have no real time behaviour, so cannot handle fast interrupt routines
• They have limited communication facilities, depending on the focus of the supplier

Compared to the other PLC classes, Nano PLCs have limited HMI features but the offered solutions are extremely cost efficient.

Micro PLCs or compact PLCs
Micro PLCs have compact CPUs with integrated I/Os. Mostly the suppliers offer a large variety of well scaled CPUs and expansion modules. Originally micro PLCs addressed the market of stand-alone machines but now they offer communication modules for networking and tele-service options. Today they can easily be remotely controlled via very cost efficient GPRS technology.

Micro PLCs typically cover a range of about 256 digital and 44 analogue I/Os. The memory capacity does not really give a comparable figure as code efficiency is very different. Most micro PLCs are very fast in operation and can handle real-time applications and interrupt functions properly and offer special functions for high speed counting, positioning and temperature control. The differentiator is not only the maximum frequency or speed, but also the engineering efforts to realise and maintain these functions afterwards. Here so-called "wizards" inside the programming tool are very helpful as they ask the programmer some details.

<table>
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<tr>
<th>Class of PLC</th>
<th>Typical housing</th>
<th>Applications</th>
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<tr>
<td>Nano PLC</td>
<td>Small bricks with display and 1/O</td>
<td>Basic replacement of relays, timers and counters in building and industry applications</td>
</tr>
<tr>
<td>Micro PLC</td>
<td>Larger bricks, modular expandable</td>
<td>Simple control in industrial and building applications</td>
</tr>
<tr>
<td>Small PLCs</td>
<td>Modular systems, comprehensive networking, technology expansions</td>
<td>Complex machine control, distributed systems, supervisory control level implemented, multiple control disciplines</td>
</tr>
<tr>
<td>Large PLC</td>
<td>Modular systems with all kind of communication, redundancy and failsafe options</td>
<td>Very complex machine control, distributed control systems, supervisory control level implemented, multiple control disciplines</td>
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Table 1: Types of controllers.
of the application and parameters of the process and then automatically generate the necessary program subroutines and data areas. This makes it easy even for beginners to implement quite complex features in their applications. For example, PID loops that normally require lots of experience are easily handled by a wizard that implements the code, with a PID auto-tune function that can solve most of these challenges later.

Communication is one of the most frequently requested features in the automation business. Here the micro PLCs can offer much more than the name "micro" lets on. Connectivity to networks like Profinet, AS-interface, Modbus and Ethernet especially is mandatory. Tele-service via landlines and wireless via Internet is expected.

Small PLCs and large PLCs

The border between these two classes of PLCs is difficult to define. Due to higher and higher integrated components on the boards, the "large" PLCs have reduced in size and the small PLCs have got more functionality.

Within these classes of PLCs the CPU has mostly no integrated I/Os. Instead they offer more onboard communication ports and a wider range of expansion modules for:

- Digital and analogue I/Os,
- Communication to all kind of bus systems,
- Special technology applications like motion control, weighting systems, closed loop control etc.

While the small PLCs focus more on the machine level, the larger units address assembly lines, continuous processes and plant-wide automation. Often they are used in redundant and failsafe systems.

The focus at these classes is no longer only to increase the PLC features but to add value to a solution through increased interoperability of different automation products like PLC, HMI, drives, sensors, motion control systems, management systems etc. Siemens started this development under the term 'Totally Integrated Automation'. It began with a common database of the most important components involved in order to eliminate working hours for re-entering the same data for several components and as a second benefit, reduction of the source for failures. At the time, PLCs, HMI and communication modules were integrated. Step-by-step drives, motion control systems, all kind of sensors, diagnostic and service information and, last but not least, interface to complete management information was implemented. Today, customers can create a holistic, homogenous concept that minimises interfaces, provides a highly transparent overview of ongoing production process and enables efficient remote maintenance. Due to the integral approach applicable to all the equipment involved, the number of technical contacts for the customer is condensed.

Choosing the right class of PLCs

In deciding which class of PLC to use, let's start with the entry level of modern automation, the Nano PLCs.

Positioning of PLCs in the entry level

Table 1 shows the positioning of conventional automation components against Nano and Micro PLCs with the relation between functionality and price. Nano PLCs filled the gap between conventional components and PLC technology.

Of course the replacement of one or two conventional components by a Nano PLC is normally not economic. But this changes as soon as flexibility and the option for later expansion are requested. Additionally, consider the overall costs, which include:

- Developing drawings
- Installation and wiring times
- Setup and test times
- System maintenance
- Spare parts handling
- Re-use of existing application programs

Altogether this can change the decision from using classical stand alone components to introducing Nano or Micro PLCs.

Nano-PLCs / Logic Modules

Decision diagram

When you have to decide which control system to use for an application, the following diagram can help guide you further. The initial questions asked are:

- What is the size of the application?
- How many digital and analogue inputs and outputs does the application require?
- What are the ranges of the analogue signals?
- What maximum frequencies will the sensors supply?
- Is communication to other systems required?
- What is the overall complexity of the application?

The last question is difficult to answer for beginners who have never seen the programming tool of a Nano PLC. But we will pick up this issue later.

The next step might be to download a demo-software from the Internet. Nearly all suppliers offer a demo-software free of charge from the Internet.

![Fig 1: Choosing the right processor.](image)

![Fig 2: The decision-process schematic.](image)
demo-software, an application can be developed and tested in the simulation mode. This means you do not have to make any investment in hardware before you have tested your application on the PC and are quite sure it will work. That makes it simple to start with a Nano PLC, as you do not take any risk, only spend some hours with an interesting engineering tool that will at the very least give you basic experience in Nano PLCs.

**Programming languages for Nano PLCs**

The basic difference is the main programming language. Typically two languages are used:

- Function block diagram, or
- Ladder diagram

Siemens is the only supplier offering both languages with full test functions in both languages. It is difficult or impossible to clearly state which programming language is the best one for Nano PLCs. It depends mostly on the background of the programmer and his personal preferences. Engineers with experience in PLC programming often like the first approach with a ladder diagram as it reminds them of the wiring diagram. And for applications which just handle a few contacts with simple logic function like "AND" or "OR" it is quite efficient. As soon as more functions like timers, counters, analogue signal processing are requested, the function block diagram can show its benefits. In these cases you get a much better overview of the total function of your application and it is easier to do diagnostics. Also the efficiency of the internal memory is higher with the function block diagram.

Some examples are shown in Fig. 3 to Fig. 5.

**HMI possibilities**

As mentioned earlier, one of the advantages of Nano PLCs is the included text display to show process parameters, operating instructions or error message without additional hardware. Depending on the application program, the operator can change parameters of timer or presets of temperature settings. But as the modules are normally mounted in a cabinet, the user has to open it to see the internal display. Nowadays, nearly all suppliers of Nano PLCs offer remote human machine interface (HMI), especially text displays that can be mounted at a convenient place for the operator.

They have different concepts of operation. Some need special communication modules and different software to design the application. Some can be configured with the standard software of the Nano PLC itself. With the LOGO! system, the LOGO! TD can be directly connected to all the basic module of the latest generation. The configuration is done like the internal display and then just choose on which of the screens you want to show the message: on the LOGO! itself or on the LOGO! text display - or on both.

**Communication to other systems, SMS messaging and telservice**

The communication options of Nano PLCs are quite different, depending on the application focus of the supplier. For industrial applications most offer AS-interface communication. For building applications LOGO! is the only system which offers full integration to the KNX Bus system (the former European Installation Bus, EIB). There are also solutions for the LON system available.

With external components you even have the option to send alarm messages to a mobile phone or switch device from a remote place via SMS. Even teleservice via a standard telephone line is possible, so you can change programs and parameters from remote places and reduce service trips to a minimum.

**Application examples**

Some application examples show the power and ease of use of Nano PLCs. The program samples just give the basic program parts for that application. You may always add some timers to run at special times, some access control for the gates or operating instructions and error message. But we want to focus on the basics.

**Energy saving by use of solar collectors**

In a house, energy should be saved by using a solar collector to warm up the water. When the water in the solar collector reaches a predefined temperature the geyser will be switched off and a pump will move the warm water of the solar collector into the warm water boiler.
Gate control system

A gate can easily be controlled by a Nano PLC with lots of extra functions that the standard solutions don’t offer. This sample is already quite complex as it includes limit switches, infra red remote control, light barriers, light signalling and emergency STOP.

Different solutions for staircase light control

All Nano PLCs offer special functions for light control systems. The simplest is just a timer to turn off the staircase light after a defined time. But you may also have an indication short time before light turns off to warn people in the staircase to extend the time by pushing the next light switch. You may change the function to a constant light just by pushing the button for a longer time period, maybe 2 s. You may use one switch as a master switch that turns ON or OFF all staircase and floor lights during the night. There are hundreds of options for different needs.

The number of park bays is given at a park deck. The number of cars inside the park deck is monitored and the green traffic light will indicate "free space" the red one shows "occupied".

In a multi-storey building, the pressure in the water supply system could be controlled automatically. A sensor detects the actual pressure in the tube system and a speed controlled pump can increase the actual pressure if necessary. As Nano PLCs can mostly handle analogue signals this job can easily be done by them. But they can also monitor the operation hours of the pump, control the switch over of the working unit and a standby unit in case of a fault of the first pump, and can show all parameters and messages. They can even handle access control to the control room.

The interesting aspect is that for all of these applications, there are individual controllers available. But with a Nano PLC, you can handle all these functions together in a single controller, combine the functionality and add comfort features that are nice to have, but you would normally not implement them seperately. This brings more comfort in the house and reduces overall costs.

Conclusion

The samples show that the low end of automation covered by Nano PLCs has advantages to offer for building applications, as the solutions are very cost efficient and easy to realise. Therefore you can save a lot of energy and money by implementing Nano PLCs in residential or commercial building applications.

Contact Josef Ploch, Siemens, Tel 011 652-2707, josef.ploch@siemens.com