الفصل الاول

مدخل الى التقنيات الرقمية المبرمجة

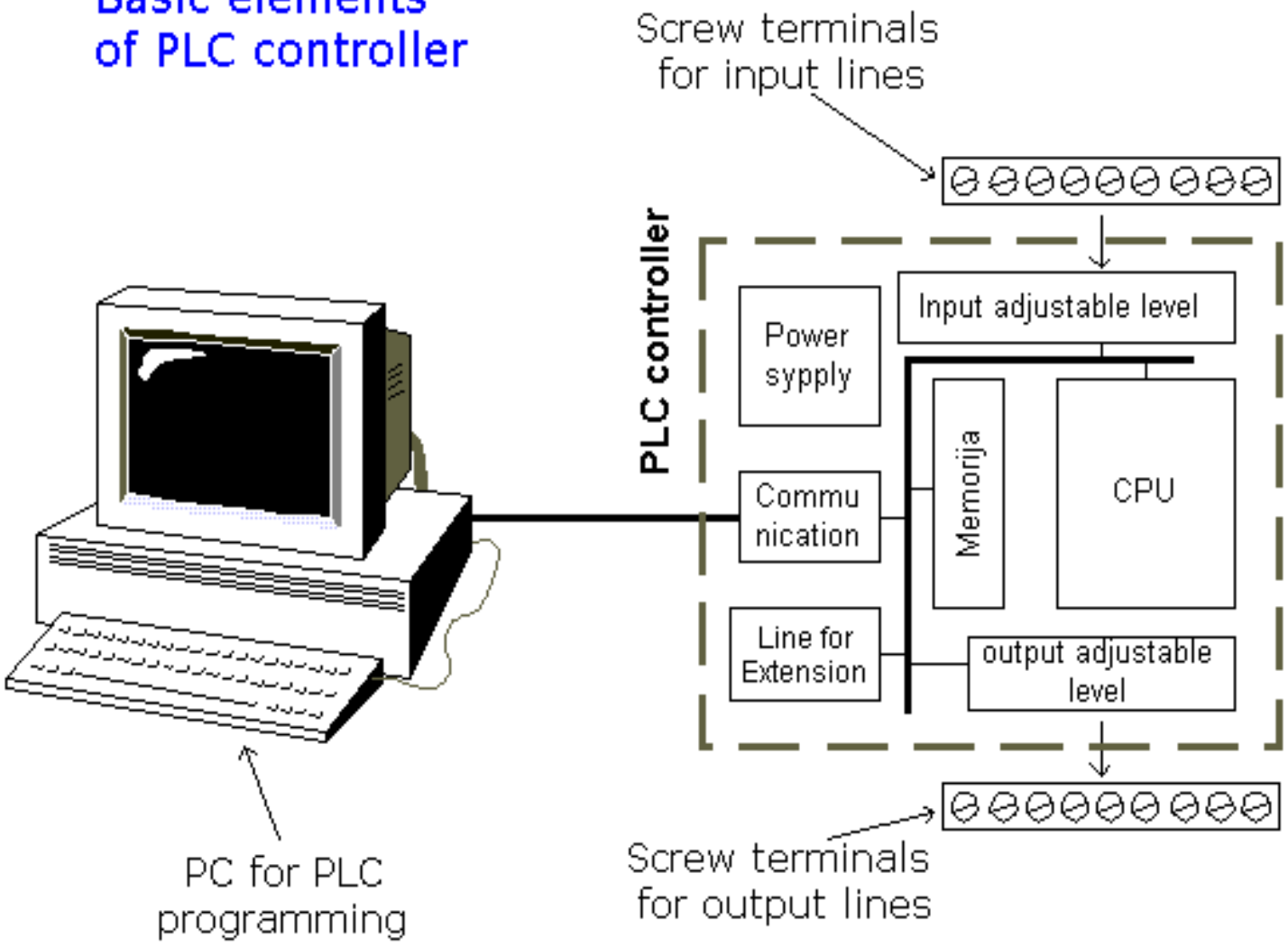
The term 'programmable logic controller' is defined as follows by IEC 1131, Part 1:

" *PLC is a digitally operating electronic system, designed for use in an industrial environment, which uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic, to control, through digital or analog inputs and outputs, various types of machines or processes. Both the PC and its associated peripherals are designed so that they can be easily integrated into an industrial control system and easily used in all their intended functions.* "

So we can say that programmable logic controller is therefore nothing more than

a microcomputer, tailored specifically for certain control tasks

Basic elements of PLC controller



Central Processing Unit - CPU

Central Processing Unit (CPU) is the brain of a PLC controller. CPU itself is usually one of the microcontrollers. Aforetime these were 8-bit microcontrollers such as 8051, and now these are 16- and 32-bit microcontrollers. Unspoken rule is that you'll find mostly Hitachi and Fujicu microcontrollers in PLC controllers by Japanese makers, Siemens in European controllers, and Motorola microcontrollers in American ones. CPU also takes care of communication, interconnectedness among other parts of PLC controller, program execution, memory operation, overseeing input and setting up of an output. PLC controllers have complex routines for memory checkup in order to ensure that PLC memory was not damaged (memory checkup is done for safety reasons). Generally speaking, CPU unit makes a great number of check-ups of the PLC controller itself so eventual errors would be discovered early. You can simply look at any PLC controller and see that there are several indicators in the form of light diodes for error signalization

Function of input and output module

- The function of an **input module** is to convert incoming signals from **sensors** into signals which can be processed by the PLC and to pass these to the central control unit.
- The reverse task is performed by an **output module**. This converts the PLC signal into signals suitable for the **actuators**

PLC controller inputs

Intelligence of an automated system depends largely on the ability of a PLC controller to read signals from different types of sensors and input devices. Keys, keyboards and by functional switches are a basis for man versus machine relationship. On the other hand, in order to detect a working piece, view a mechanism in motion, check pressure or fluid level you need specific automatic devices such as proximity sensors, marginal switches, photoelectric sensors, level sensors, etc. Thus, input signals can be logical (on/off) or analogue. Smaller PLC controllers usually have only digital input lines while larger also accept analogue inputs through special units attached to PLC controller. One of the most frequent analogue signals are a current signal of 4 to 20 mA and milivolt voltage signal generated by various sensors. Sensors are usually used as inputs for PLCs. You can obtain sensors for different purposes. They can sense presence of some parts, measure temperature, pressure, or some other physical dimension, etc. (ex. inductive sensors can register metal objects).

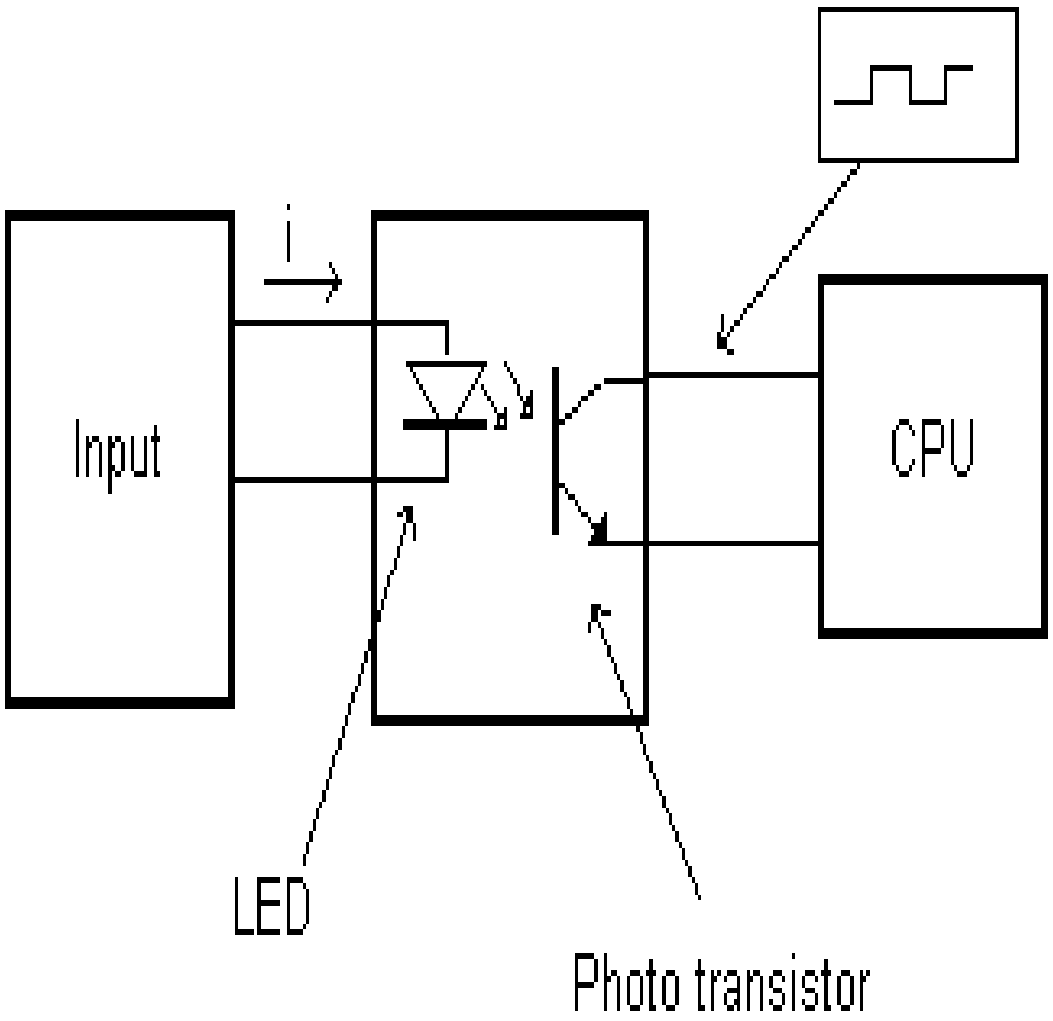
Other devices also can serve as inputs to PLC controller. Intelligent devices such as robots, video systems, etc. often are capable of sending signals to PLC controller input modules (robot, for instance, can send a signal to PLC controller input as information when it has finished moving an object from one place to the other.)

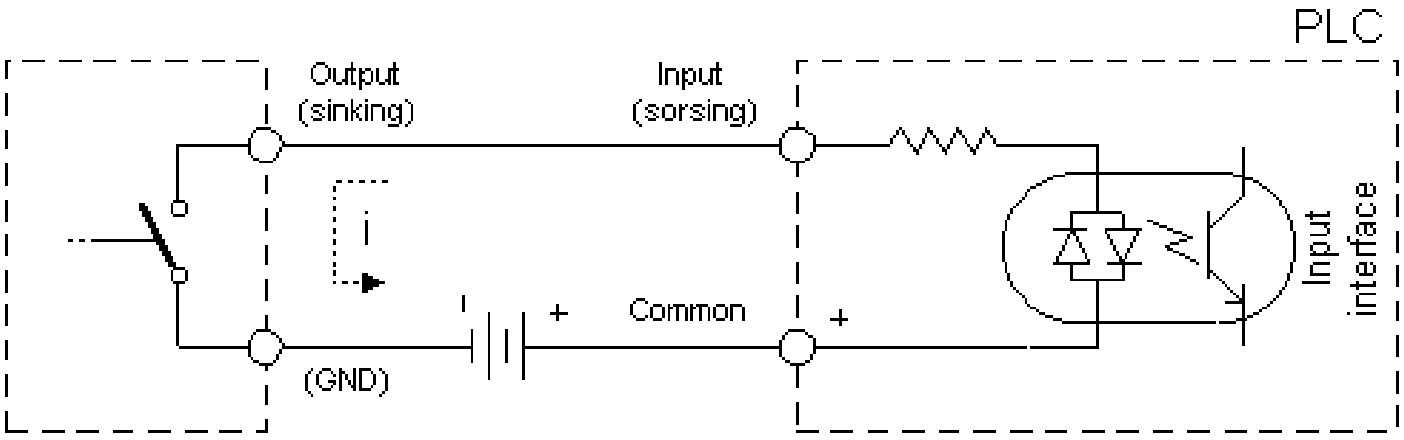
Input adjustment interface

Adjustment interface also called an interface is placed between input lines and a CPU unit. The purpose of adjustment interface to protect a CPU from disproportionate signals from an outside world. Input adjustment module turns a level of real logic to a level that suits CPU unit (ex. input from a sensor which works on 24 VDC must be converted to a signal of 5 VDC in order for a CPU to be able to process it). This is typically done through opto-isolation, and this function you can view in the following picture.

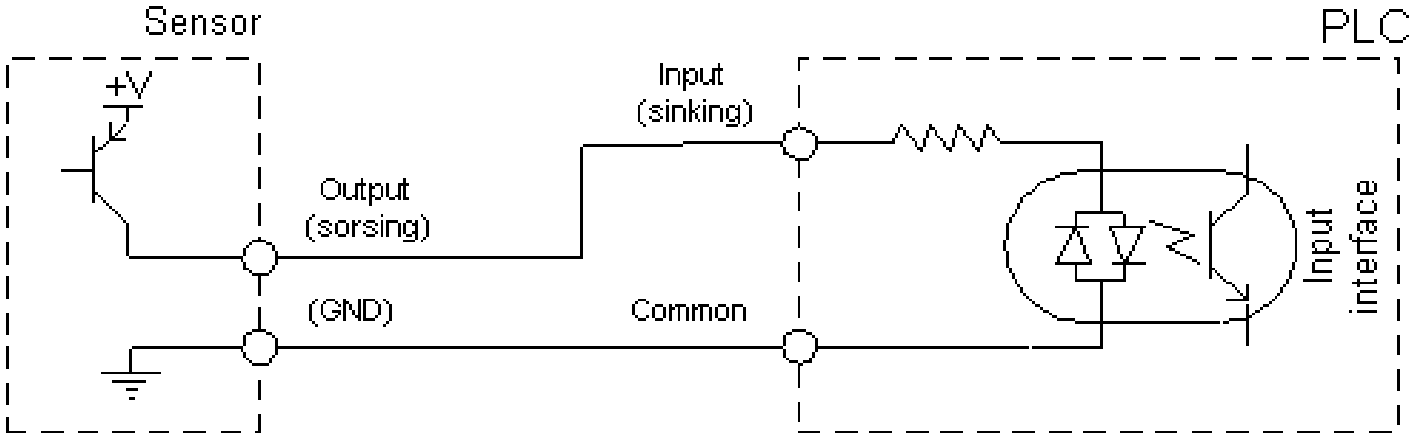
Opto-isolation means that there is no electrical connection between external world and CPU unit. They are "optically" separated, or in other words, signal is transmitted through light. The way this works is simple. External device brings a signal which turns LED on, whose light in turn incites photo transistor which in turn starts conducting, and a CPU sees this as logic zero (supply between collector and transmitter falls under 1V). When input signal stops LED diode turns off, transistor stops conducting, collector voltage increases, and CPU receives logic 1 as information.

Input adjustable interface





Connecting sensors with sinking output to a PLC controller sourcing input



Connecting sensors with a sourcing output to a PLC controller sinking input

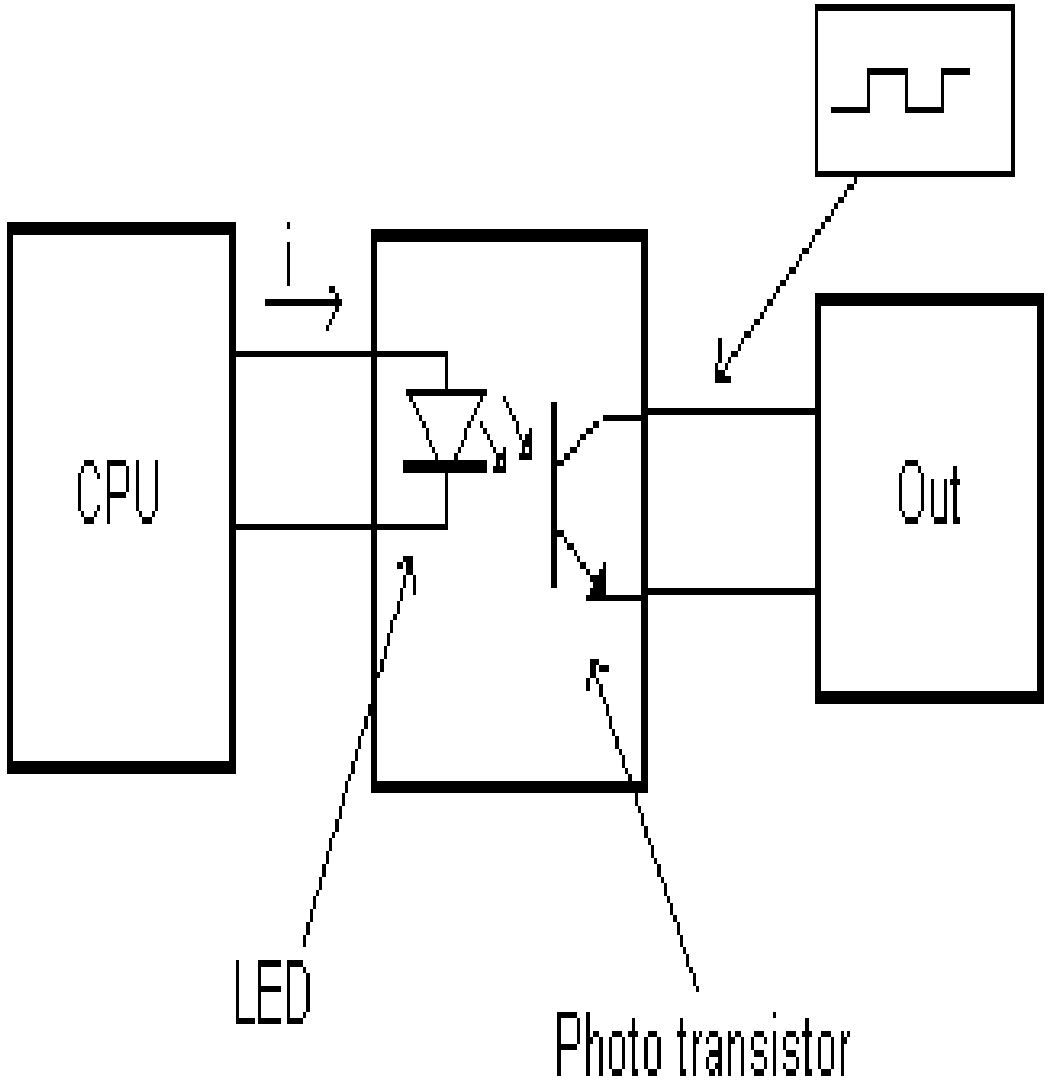
PLC controller output

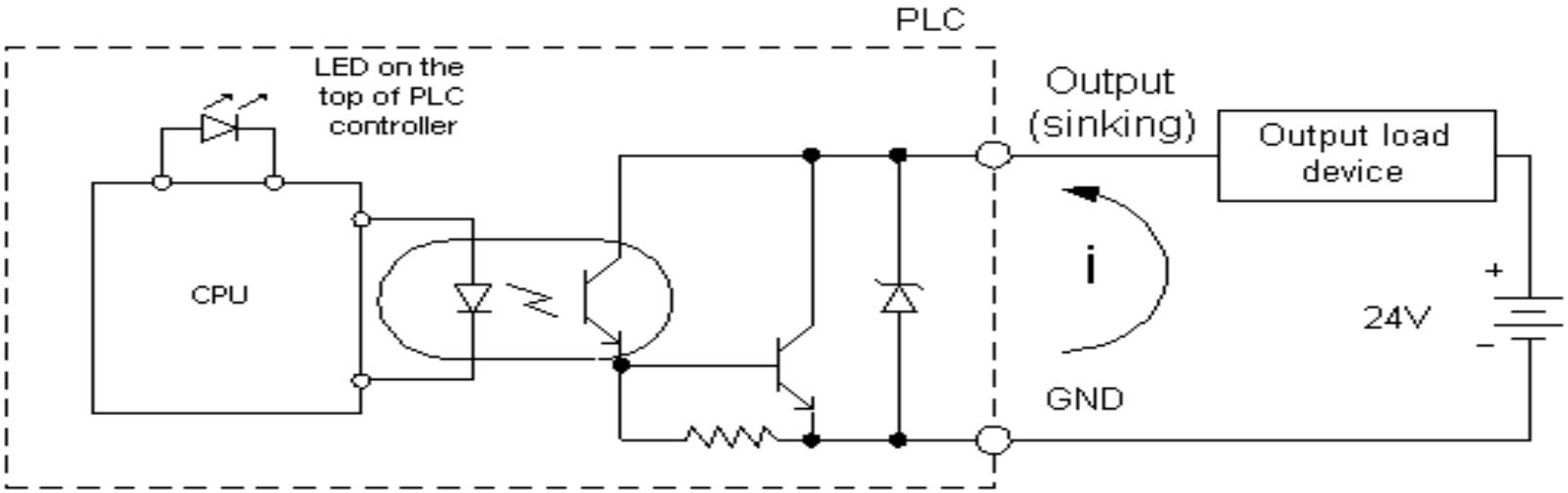
Automated system is incomplete if it is not connected with some output devices. Some of the most frequently used devices are motors, solenoids, relays, indicators, sound signalization and similar. By starting a motor, or a relay, PLC can manage or control a simple system such as system for sorting products all the way up to complex systems such as service system for positioning head of CNC machine. Output can be of analogue or digital type. Digital output signal works as a switch; it connects and disconnects line. Analogue output is used to generate the analogue signal (ex. motor whose speed is controlled by a voltage that corresponds to a desired speed).

Output adjustment interface

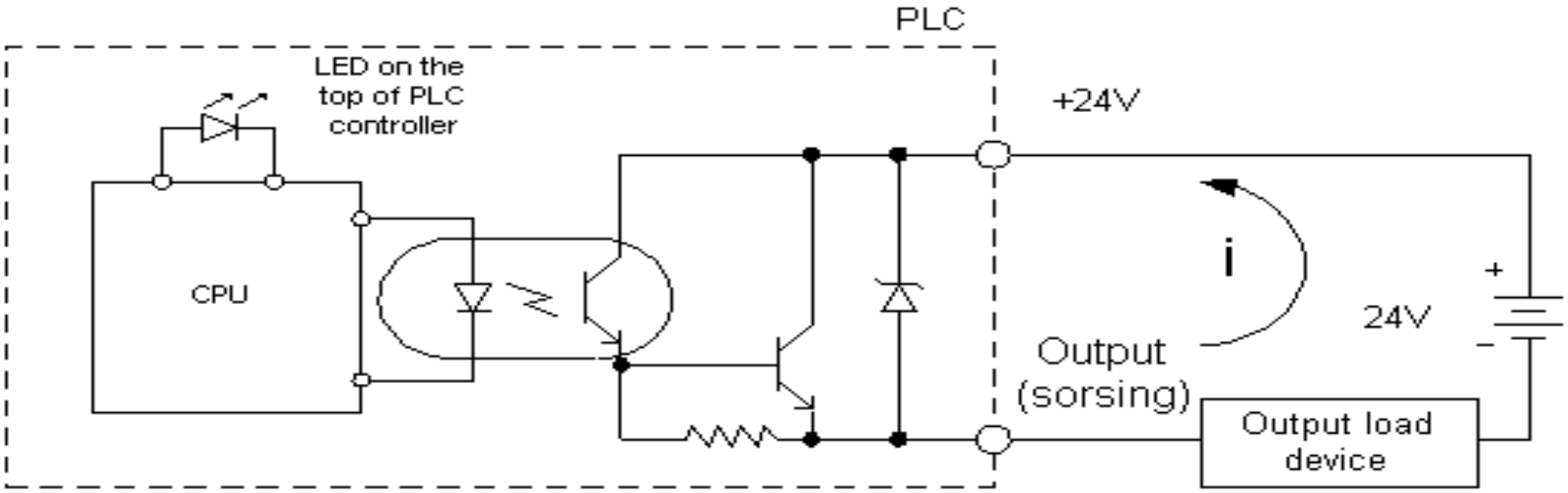
Output interface is similar to input interface. CPU brings a signal to LED diode and turns it on. Light incites a photo transistor which begins to conduct electricity, and thus the voltage between collector and emmiter falls to 0.7V , and a device attached to this output sees this as a logic zero. Inversely it means that a signal at the output exists and is interpreted as logic one. Photo transistor is not directly connected to a PLC controller output. Between photo transistor and an output usually there is a relay or a stronger transistor capable of interrupting stronger signals.

Output adjustable interface





Connecting output load device to a sinking PLC controller output



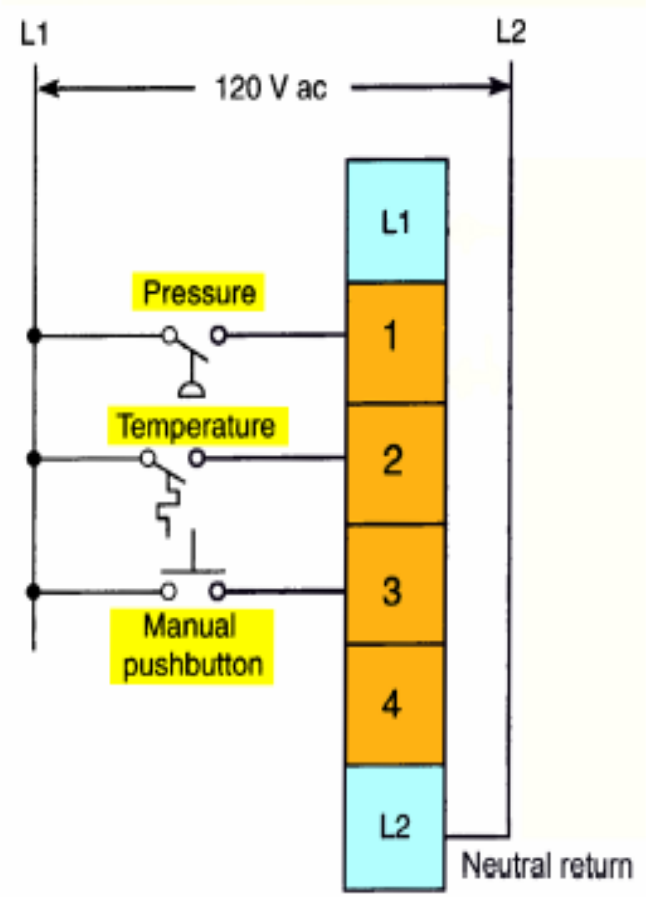
Connecting output load device to a sourcing PLC controller output

Extension lines

Every PLC controller has a limited number of input/output lines. If needed this number can be increased through certain additional modules by system extension through extension lines. Each module can contain extension both of input and output lines. Also, extension modules can have inputs and outputs of a different nature from those on the PLC controller (ex. in case relay outputs are on a controller, transistor outputs can be on an extension module).

PLC Input Module Connections

- The same input field devices are used
- These devices are wired to the input module according to the manufacturer's labeling scheme



Sensors

Sensors allow a PLC to detect the state of a process. Logical sensors can only detect a state that is either true or false. Examples of physical phenomena that are typically detected are listed below.

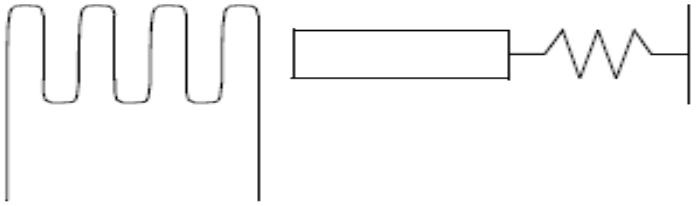
- inductive proximity - is a metal object nearby?
- capacitive proximity - is a dielectric object nearby?
- optical presence - is an object breaking a light beam or reflecting light?
- mechanical contact - is an object touching a switch?

Continuous sensors convert physical phenomena to measurable signals, typically voltages or currents. Consider a simple temperature measuring device, there will be an increase in output voltage proportional to a temperature rise. A computer could measure the voltage, and convert it to a temperature. The basic physical phenomena typically measured with sensors include;

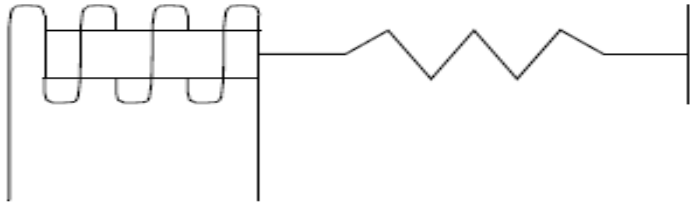
- angular or linear position
- acceleration
- temperature
- pressure or flow rates
- stress, strain or force
- light intensity
- sound

Actuator

Solenoids are the most common actuator components. The basic principle of operation is there is a moving ferrous core (a piston) that will move inside wire coil as shown



current off

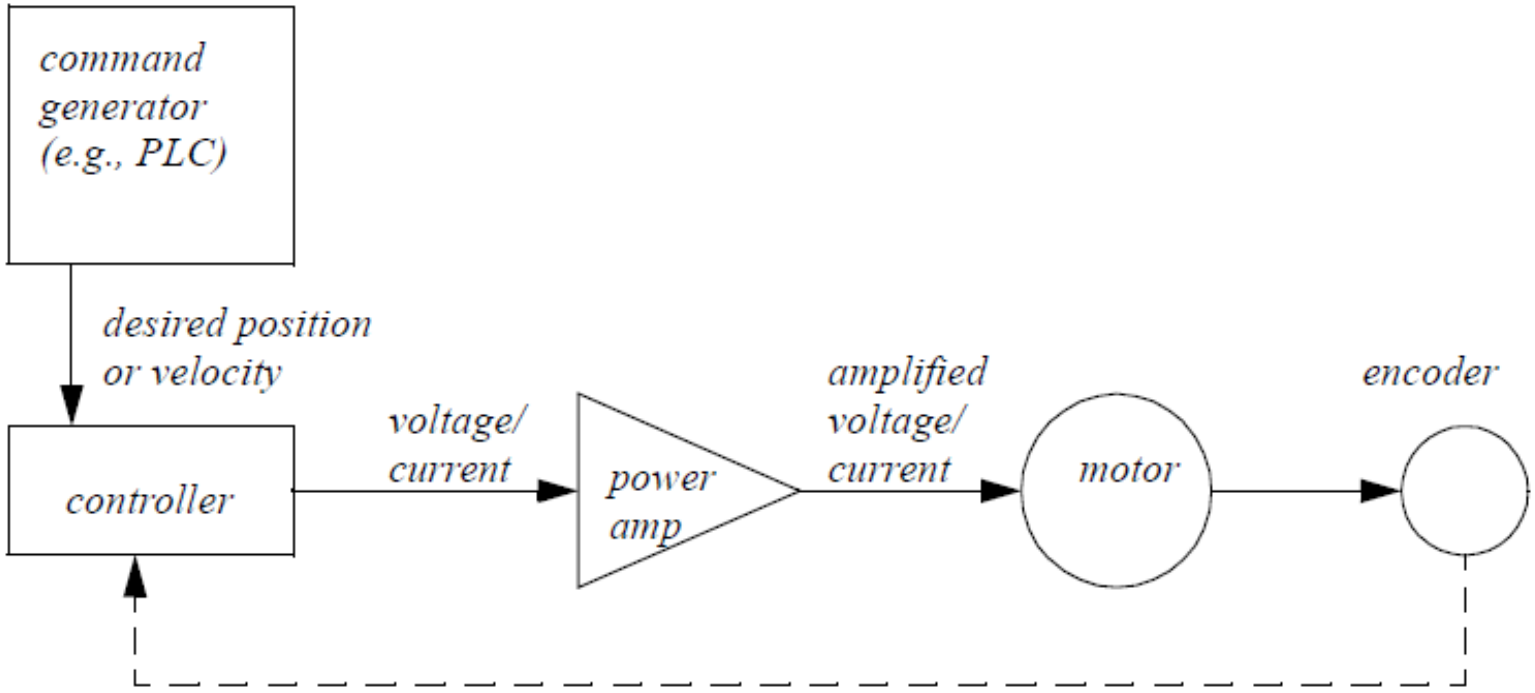


current on

An electric motor is composed of a rotating center, called the rotor, and a stationary outside, called the stator. These motors use the attraction and repulsion of magnetic fields to induce forces, and hence motion. Typical electric motors use at least one electromagnetic coil, and sometimes permanent magnets to set up opposing fields. When a voltage is applied to these coils the result is a torque and rotation of an output shaft. There are a variety of motor configuration the yields motors suitable for different applications. Most notably, as the voltages supplied to the motors will vary the speeds and torques that they will provide.

A control system is required when a motor is used for an application that requires

continuous position or velocity. A typical controller is shown in Figure 24.1. In any controlled system a command generator is required to specify a desired position. The controller will compare the feedback from the encoder to the desired position or velocity to determine the system error. The controller with then generate an output, based on the system error. The output is then passed through a power amplifier, which in turn drives the motor. The encoder is connected directly to the motor shaft to provide feedback of position.



Power supply

Electrical supply is used in bringing electrical energy to central processing unit. Most PLC controllers work either at 24 VDC or 220 VAC. On some PLC controllers you'll find electrical supply as a separate module. Those are usually bigger PLC controllers, while small and medium series already contain the supply module. User has to determine how much current to take from I/O module to ensure that electrical supply provides appropriate amount of current. Different types of modules use different amounts of electrical current.

This electrical supply is usually not used to start external inputs or outputs. User has to provide separate supplies in starting PLC controller inputs or outputs because then you can ensure so called "pure" supply for the PLC controller. With pure supply we mean supply where industrial environment can not affect it damagingly. Some of the smaller PLC controllers supply their inputs with voltage from a small supply source already incorporated into a PLC.

Memory

System memory (today mostly implemented in FLASH technology) is used by a PLC for an process control system. Aside from this operating system it also contains a user program translated from a ladder diagram to a binary form. FLASH memory contents can be changed only in case where user program is being changed. PLC controllers were used earlier instead of FLASH memory and have had EPROM memory instead of FLASH memory which had to be erased with UV lamp and programmed on programmers. With the use of FLASH technology this process was greatly shortened. Reprogramming a program memory is done through a serial cable in a program for application development.

User memory is divided into blocks having special functions. Some parts of a memory are used for storing input and output status. The real status of an input is stored either as "1" or as "0" in a specific memory bit. Each input or output has one corresponding bit in memory. Other parts of memory are used to store variable contents for variables used in user program. For example, timer value, or counter value would be stored in this part of the memory.