PLC !

Northern Technical University

Technical Institute / Mosul
Department of Electrical Technologies
Electrical powers and networks branch
2021

What is a PLC?


L N I1 I2 I3 I4 I5 I6 I7 I8
AC 110~240V
INPUT 8xAC
RIEVTECH
Pro
F1
ESC
OK
PR-12AC-R
OUTPUT 4xRelay 10A


DC12/24V
Input 8xDC (I7.I8 0-10V)
SIEMENS
B01
Ax
Par
Q1
LOGO! 12/24RC
ESC
OK
Output 4xRelay/10A

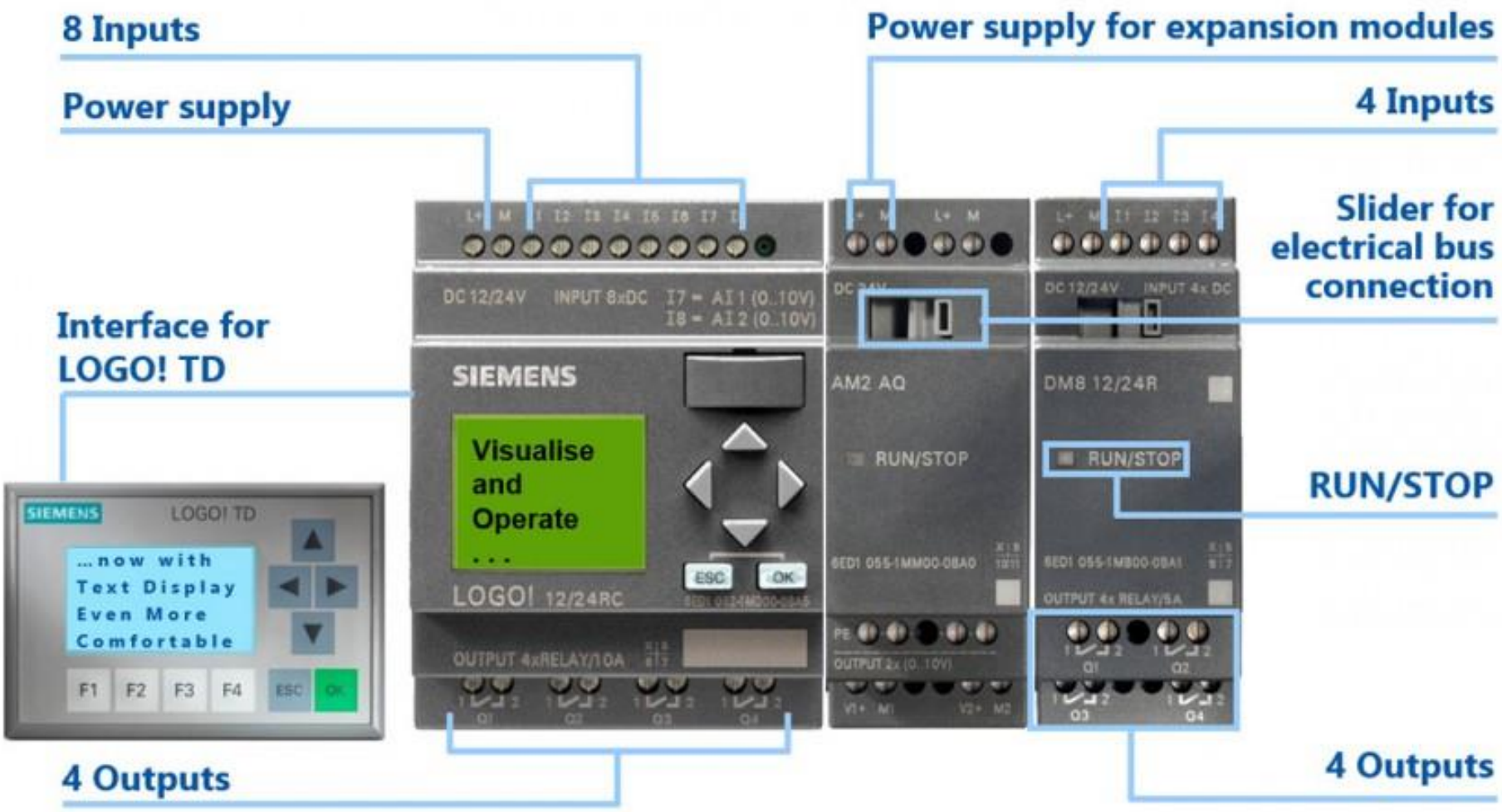

SIEMENS
SIMATIC
S7-1200


FL611
DN011A
DO835
DO835
DO835

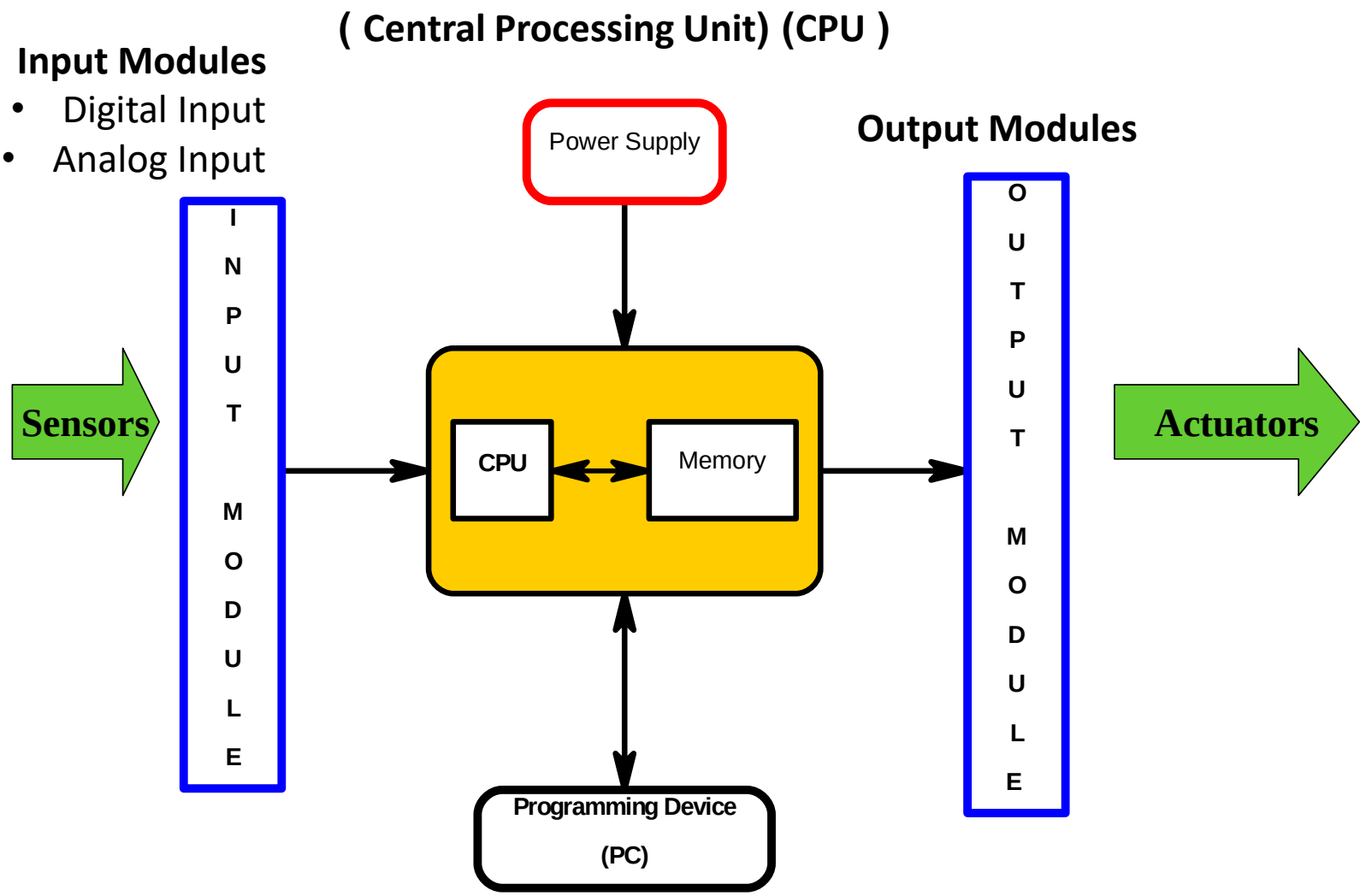
Definition of a PLC

- A programmable logic controller (PLC) is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or lighting fixtures.

PLC in general



Basic PLC operation



Advantages and Disadvantages of PLC

Advantages of programmable logic controller (PLC)

- Smaller physical size than hard-wire solutions.
- Easier and faster to make changes.
- PLCs have integrated diagnostics and override functions.
- Diagnostics are centrally available.
- Applications can be immediately documented.
- Applications can be duplicated faster and less expensively

Disadvantages of programmable logic controller (PLC)

- Upgrading issues.
- There are limitations of working of PLCs under high temperature, vibration conditions.

Inputs / Sensors

Push button

Switch ON/OFF

Inductive Sensor

Limit Switch Sensor

Laser Sensor

Pressure Sensor

Technology	Sensing range	Applications	Target materials
Inductive 	<4-40 mm	Any close-range detection of ferrous material	Iron Steel Aluminum Copper etc. 
Capacitative 	<3-60 mm	Close-range detection of non-ferrous material	Liquids Wood Granulates Plastic Glass etc. 
Photoelectric 	<1mm- 60 mm	Long-range, smalll or large target detection	Silicon Plastic Paper Metal etc. 
Ultrasonic 	<30 mm- 3 mm	Long-range detection of targets with difficult surface properites. Color/reflectivity insensitive.	Cellophane Foam Glass Liquid Powder etc. 

Outputs / Actuators

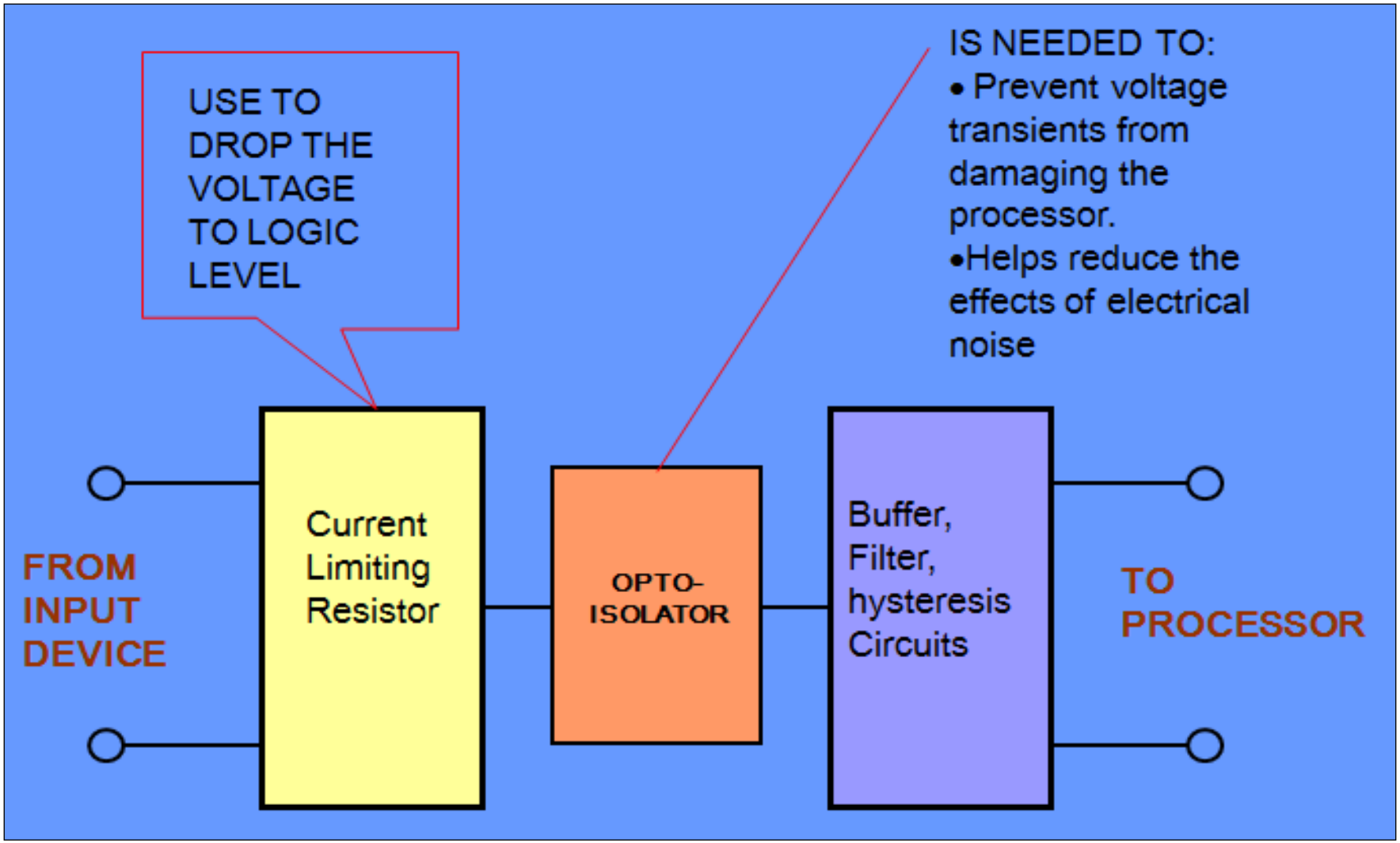
Contactor

Light Signal

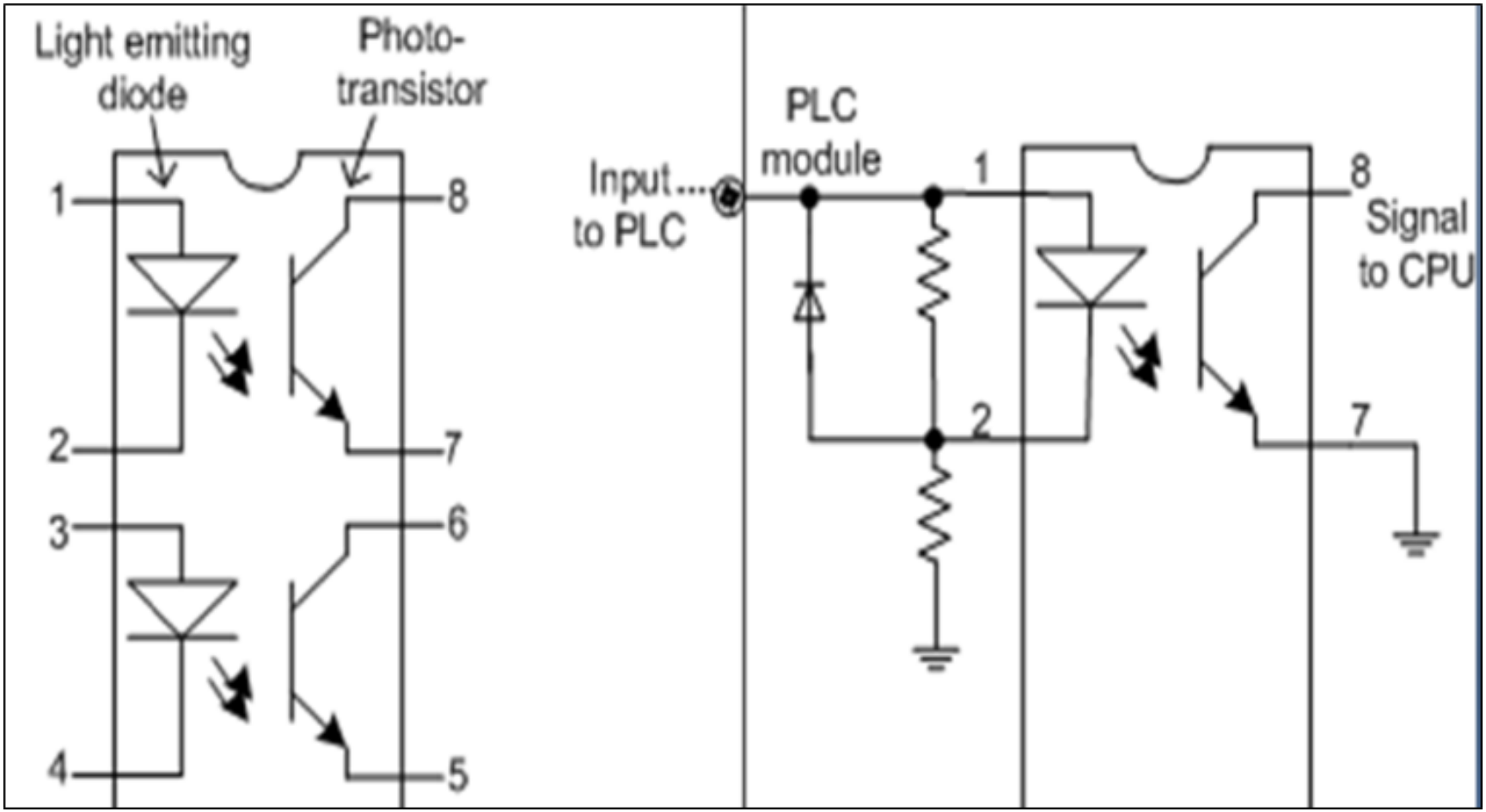
Electrical Valve

Input / Output scheme

DC Input Module

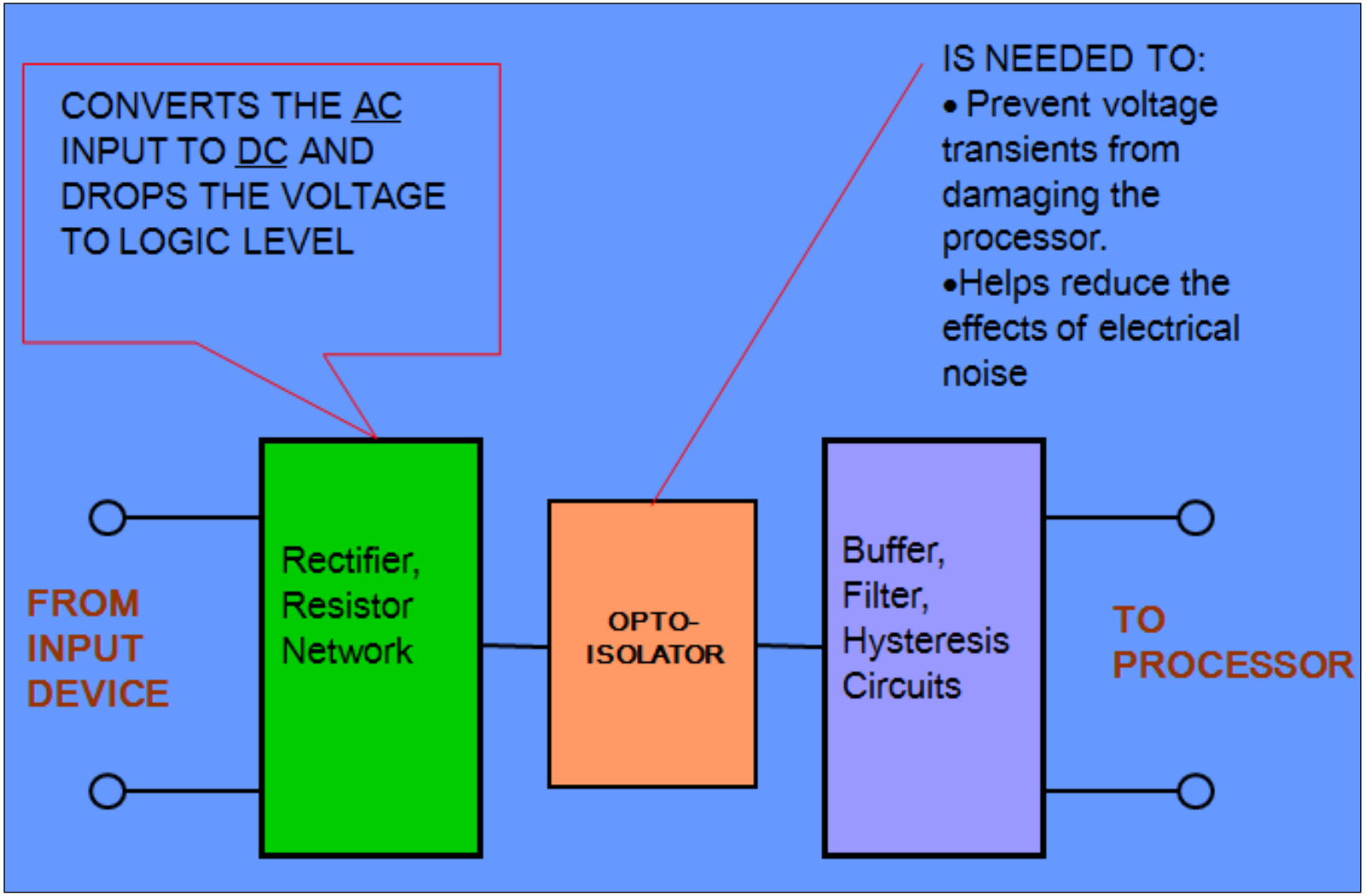


DC Input Module

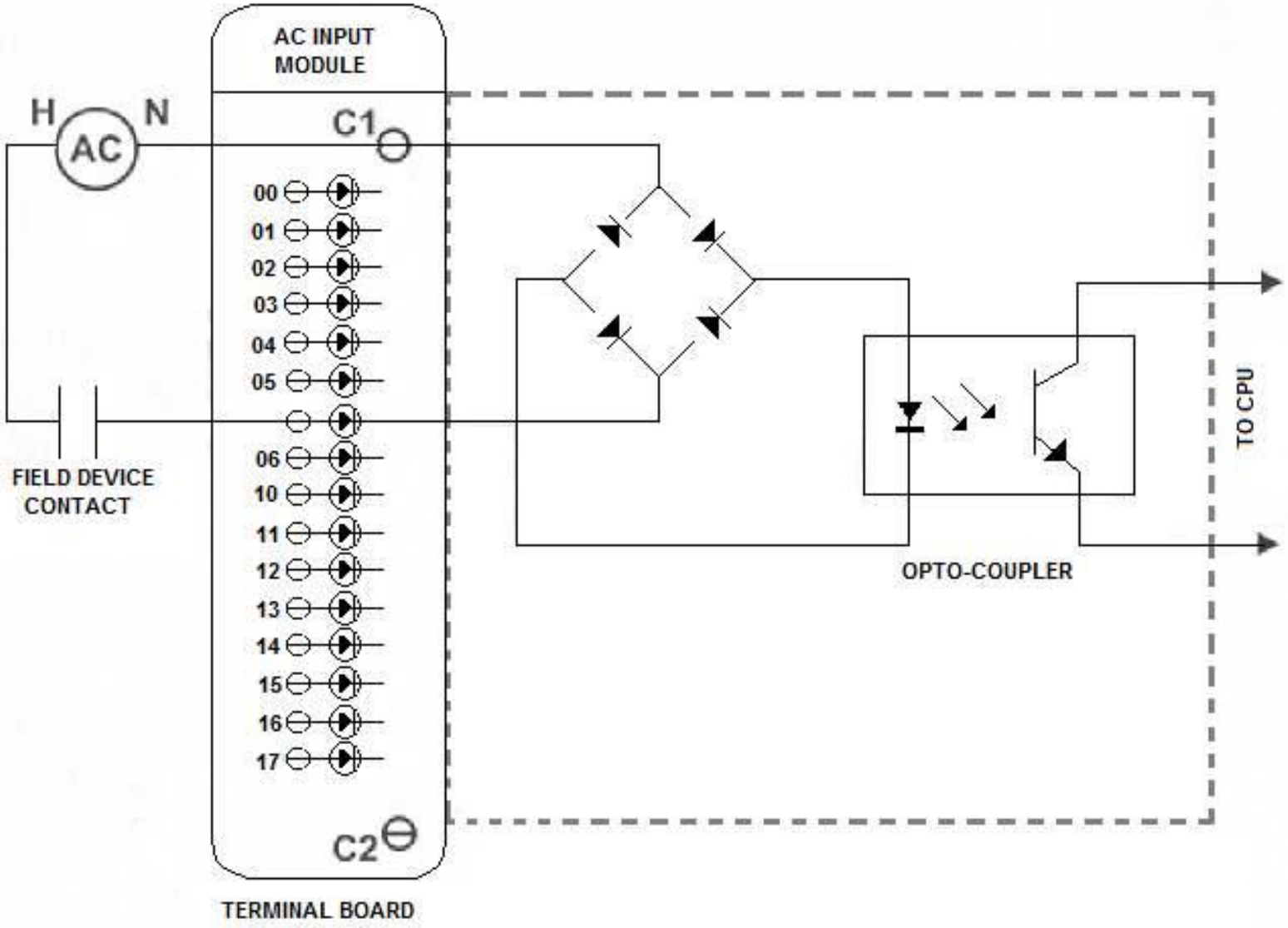


Input / Output scheme

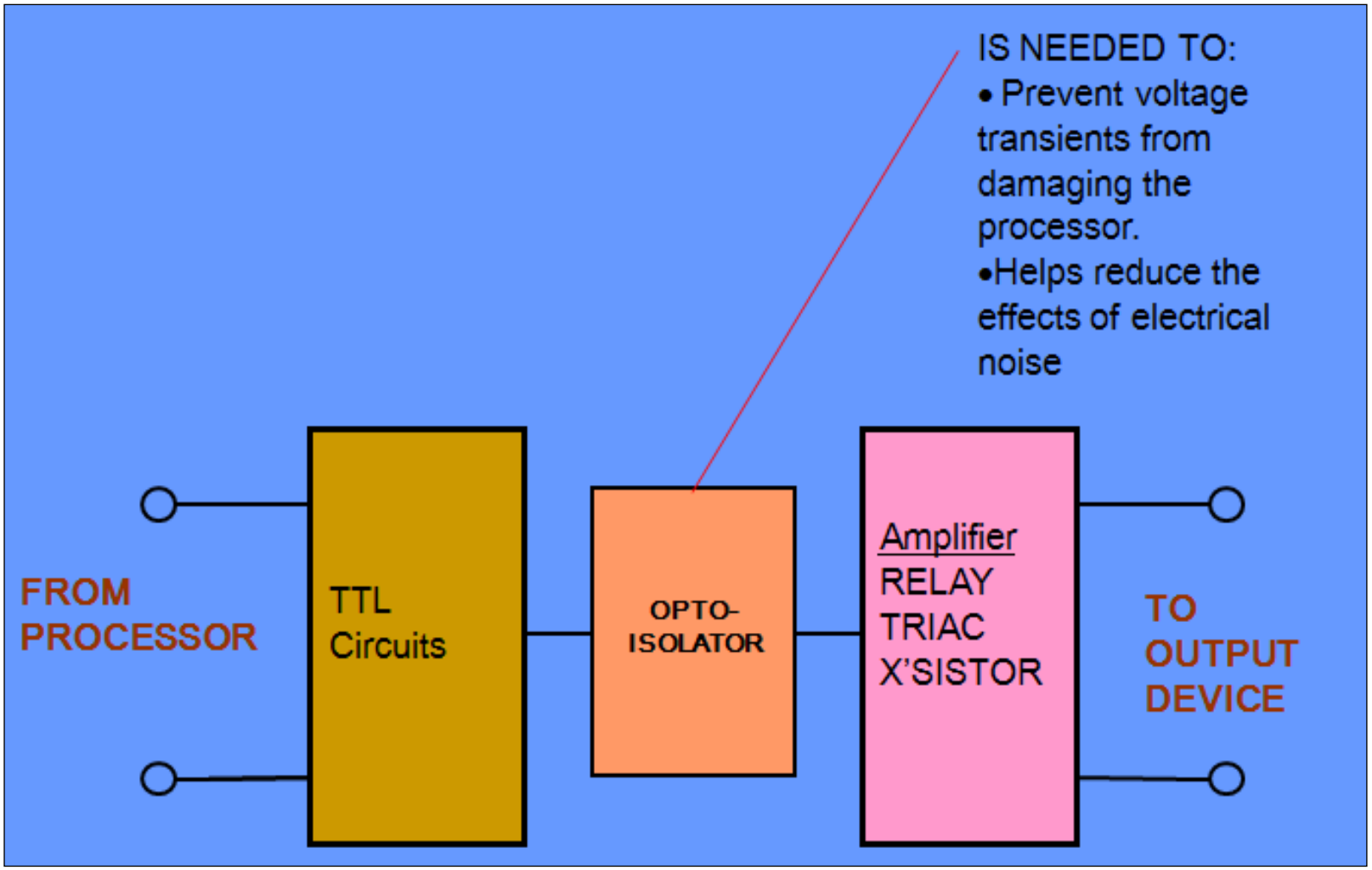
AC Input Module



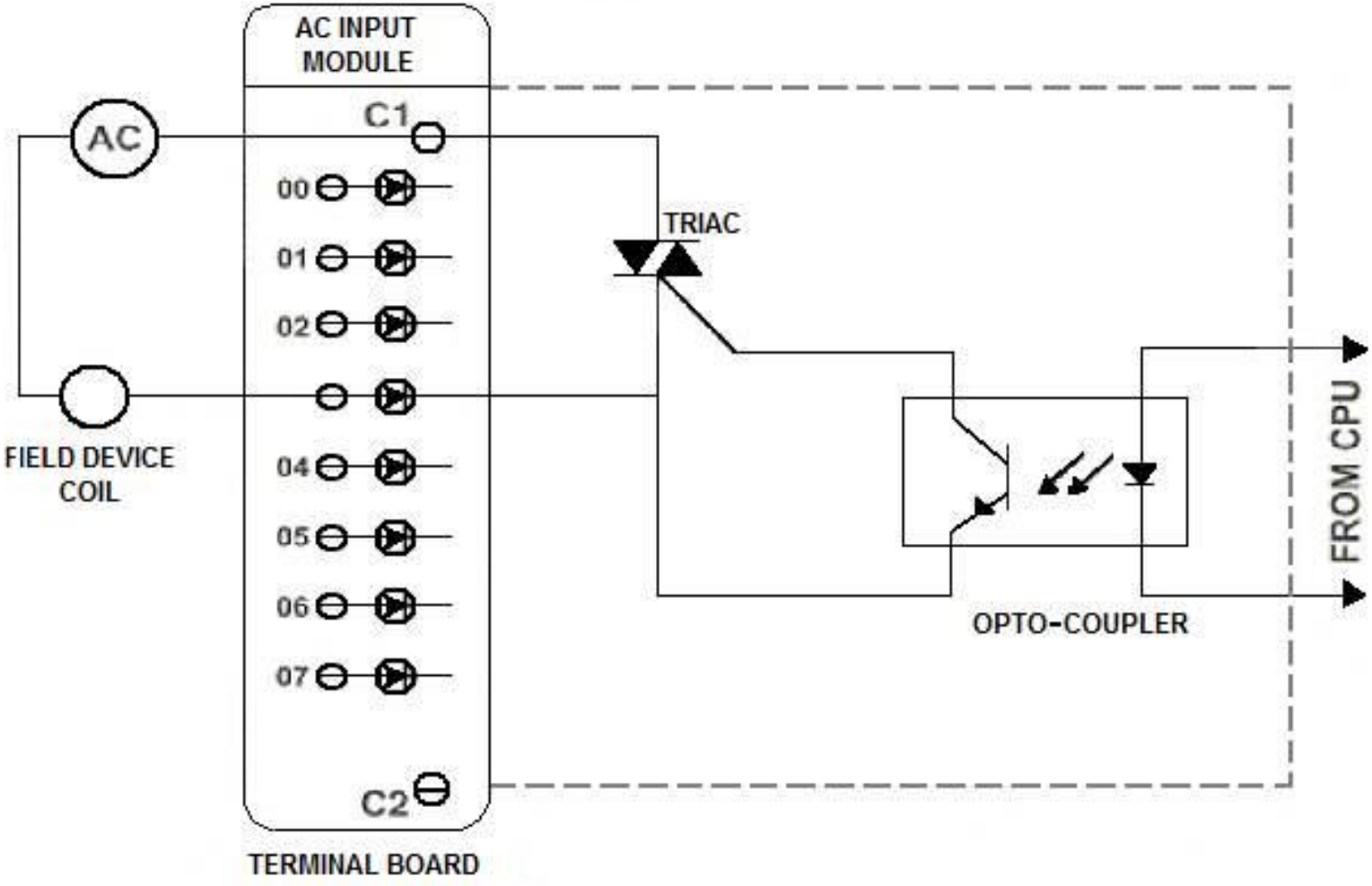
AC Input Module



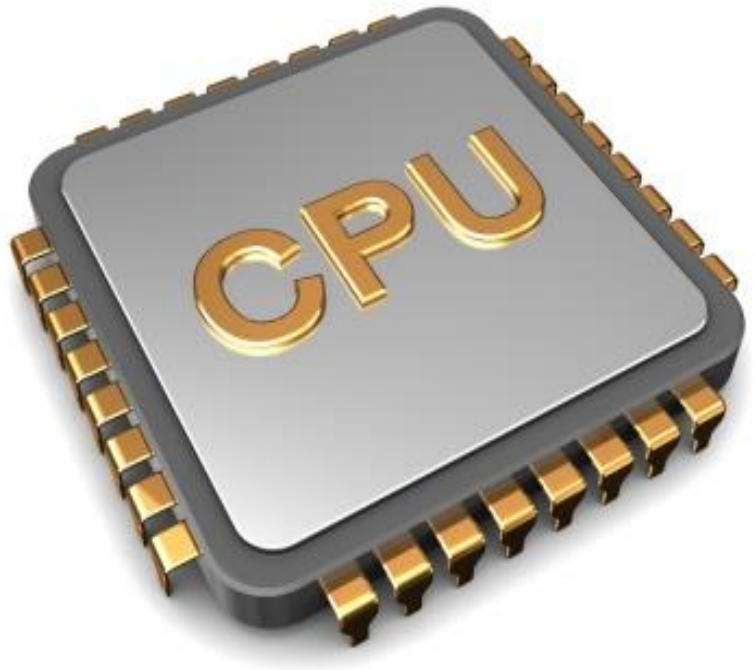
Output Module



Output Module



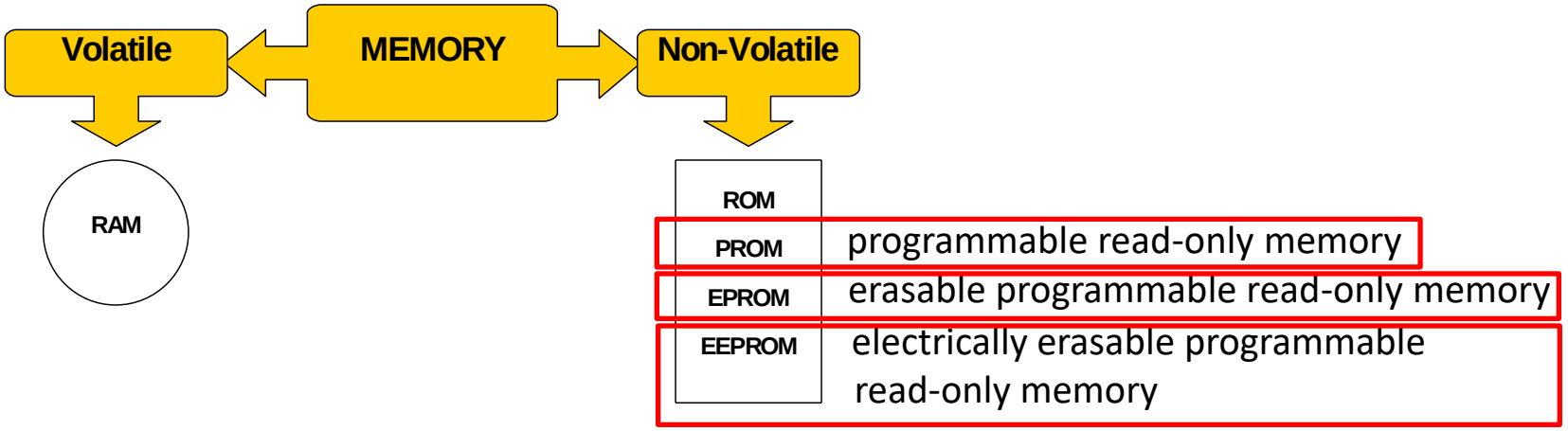
(CPU)
(Central Processing Unit)



CPU

- The central processor unit (CPU) is a microprocessor system that contains the memory of the system and is the PLC decision making unit. The CPU monitors the inputs and makes decisions based on instructions held in the program memory. The CPU performs relay, counting, timing, data comparison, and sequential operations.

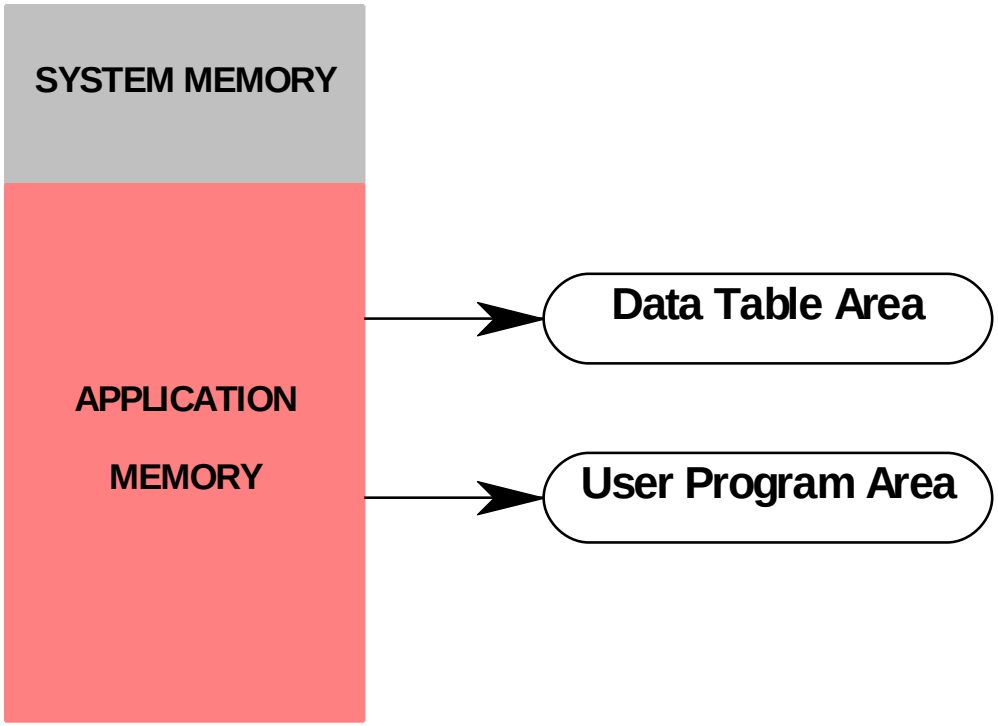
Memory of the PLC System



RAM: Random-access memory is a form of computer memory that can be read and changed in any order, typically used to store working data and machine code.

ROM: Read-only memory is a type of non-volatile memory used in computers and other electronic devices. Data stored in ROM cannot be electronically modified after the manufacture of the memory device.

Memory of the PLC Applications



Data Table Area: The numbers (values), time, and variables are stored, adjustable and monitored.

User Program Area: We only put the program that we want to design

Basic programming elements

1. Real Signals.
2. Software Signals.
3. Software Functions.

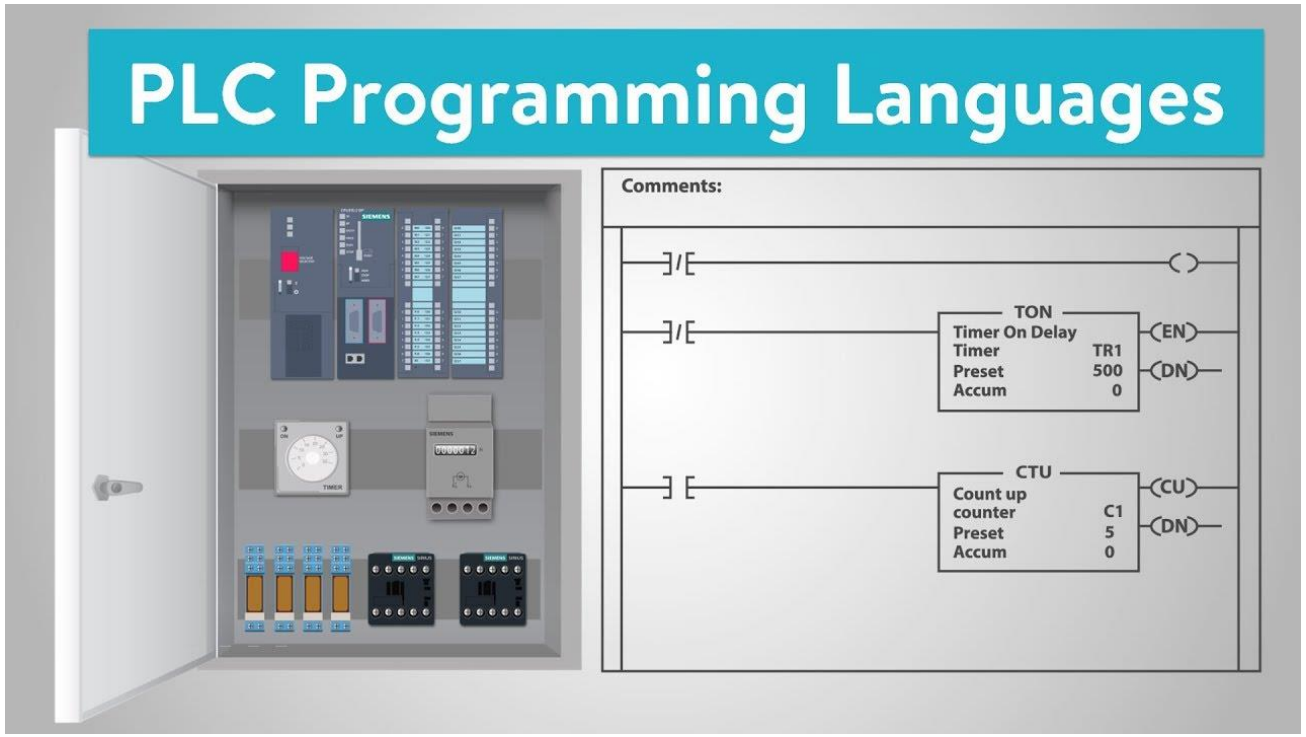
Real Signals.
Consist of:
1. Digital input signals (I)
2. Digital output signals (Q)
3. Analog input signals (AI)
4. Analog output signals (AO)

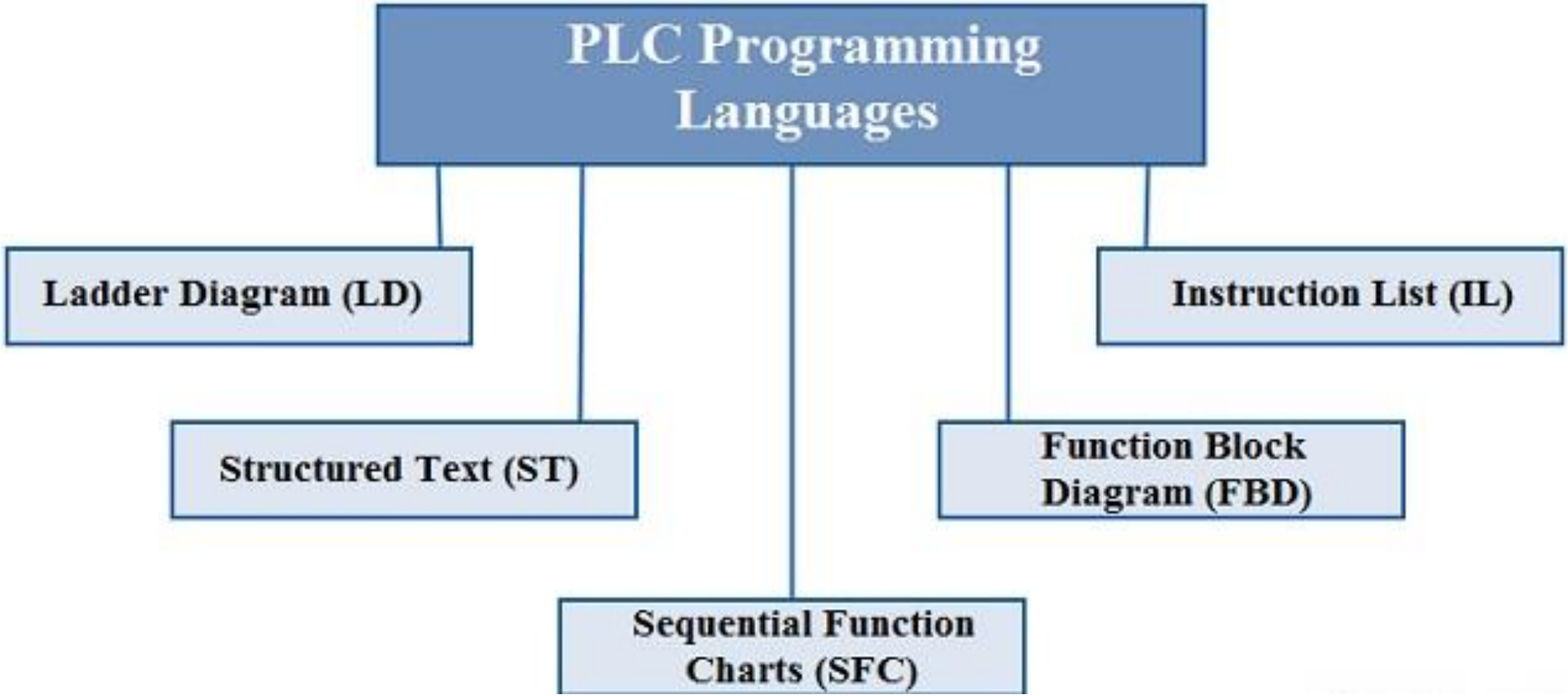
Thanks

Next Lecture

Programming Languages

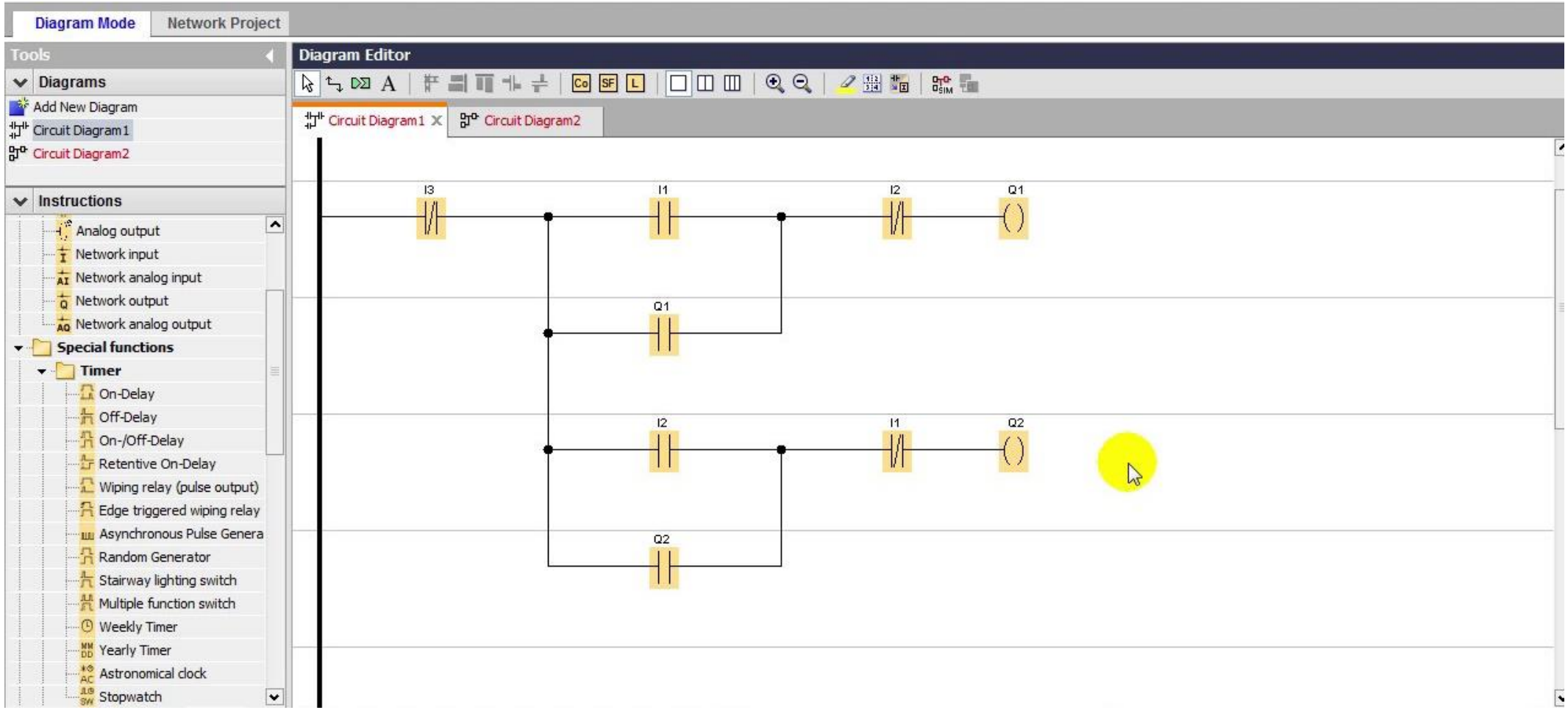
PLC Programming Languages




PLC Programming Languages
Ladder Diagram (LD)
Structured Text (ST)
Sequential Function Charts (SFC)
Function Block Diagram (FBD)
Instruction List (IL)

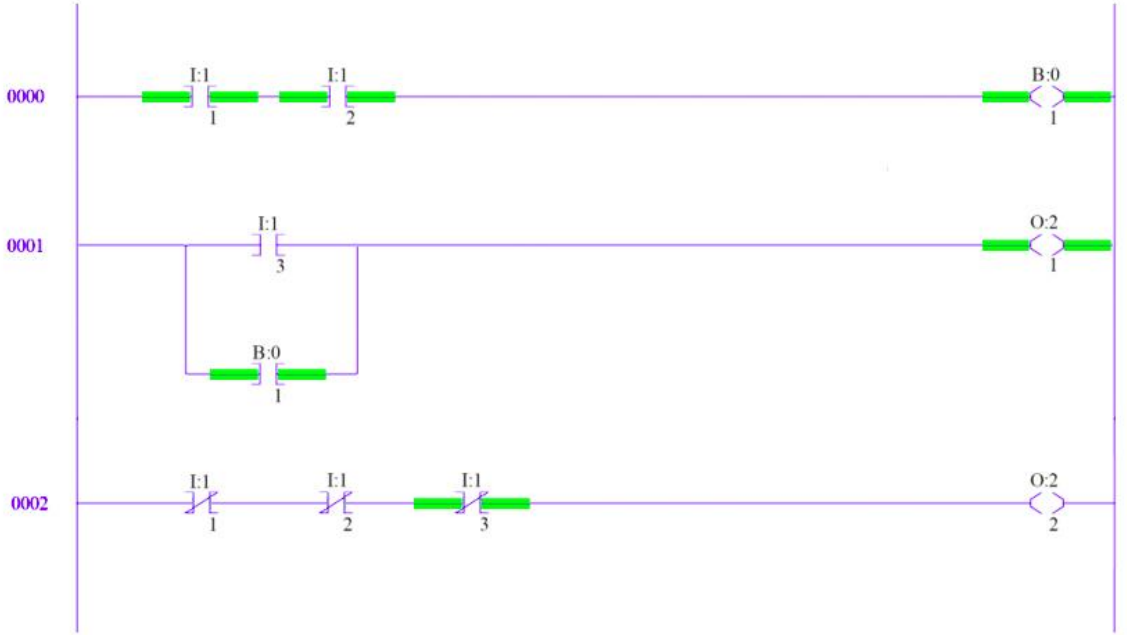
Programming using the Ladder Diagram language

LD (Ladder Diagram)



LD (Ladder Diagram)

Ladder logic is a PLC programming language. It is really called ladder diagram or just LD, but most people refer to it as ladder logic. There's a very simple reason for its name. Ladder logic is made of rungs making what looks like a ladder.



Ladder Logic Programming with Instructions

Each symbol in ladder logic is an instruction.كل رمز في المنطق السلمي هو امر معين

Symbols of Ladder Logic languages

The programming language of the ladder logical for PLC unit consists of a set of symbols that are used to represent the controls and instructions. We must know that these symbols are not physical elements but rather a software program, as follows:

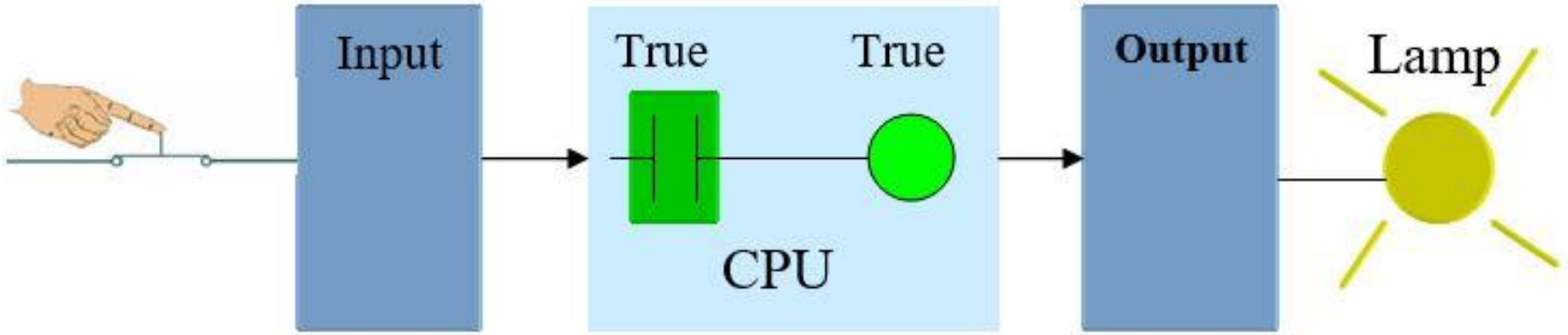
تتكون لغة البرمجة بالسلم المنطقي لوحدة المتحكمات المنطقية القابله للبرمجة من مجموعة من الرموز تستخدم لتمثل عناصر التحكم و التعليمات ويجب أن نعلم أن هذه الرموز ليست عناصر فيزيائية بل هي عبارة عن برمجيات وهي كالتالي:

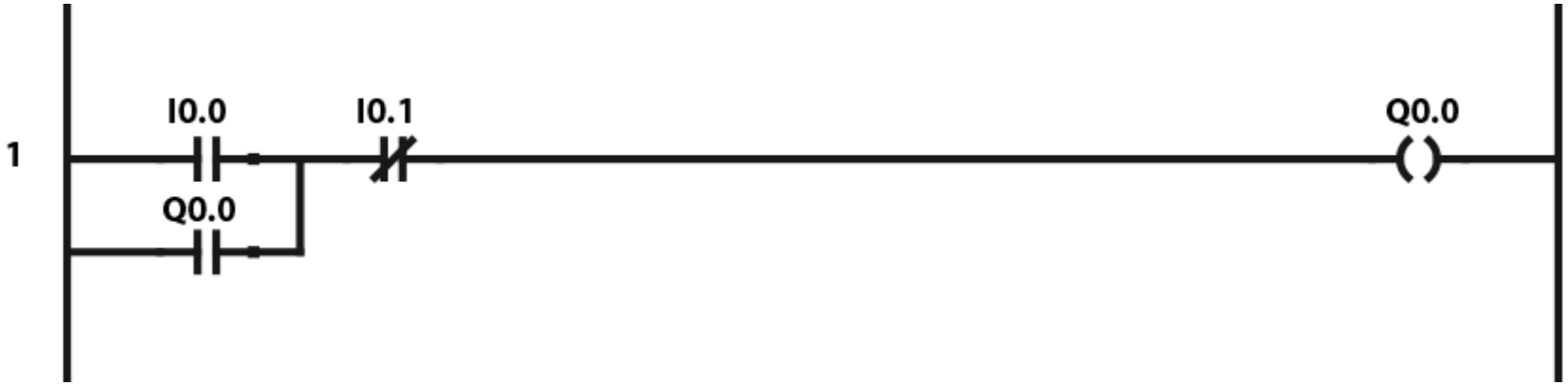
الملامسات المفتوحة طبيعياً (NO) Normally Open Contacts

الملامسات المغلقة طبيعياً -(NC) Normally Closed Contacts

Symbols of Ladder Logic languages

الملفات —( )— (Coils)

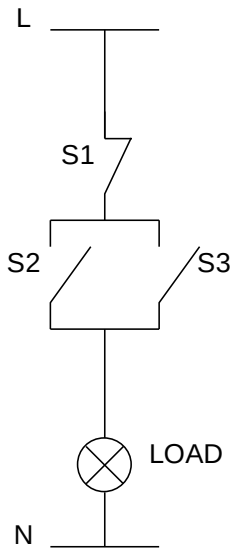




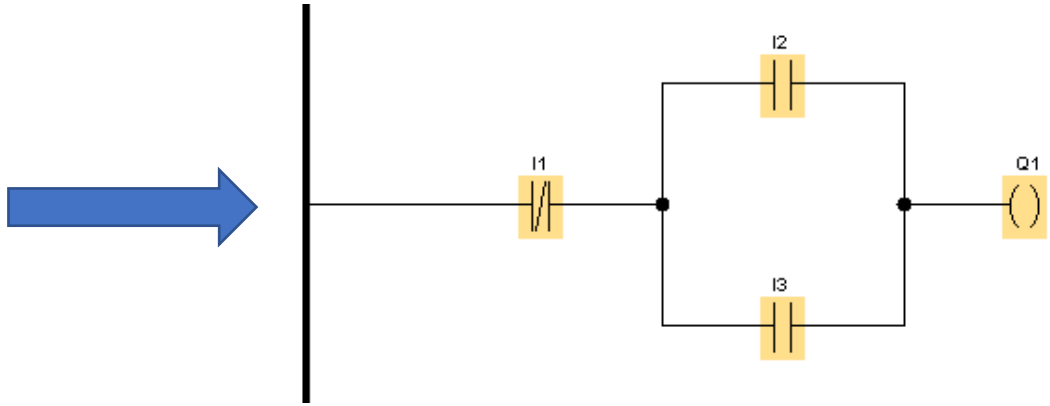
Applications

Ladder Logic Programming

Operating a load from two different points.



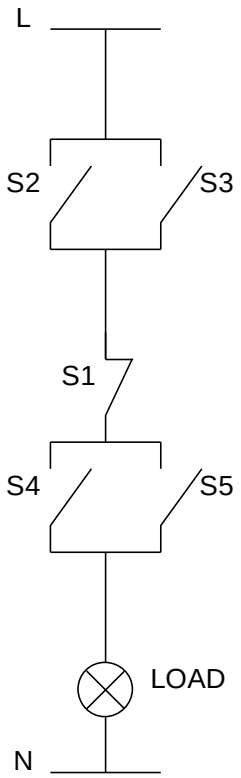
Electrical Circuit



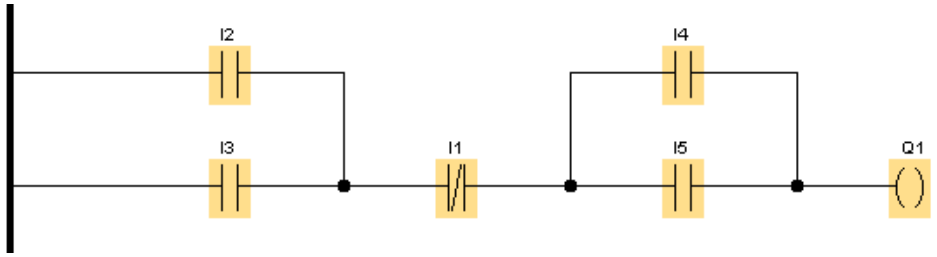
Ladder Diagram

Applications

Operating a load from four different points.



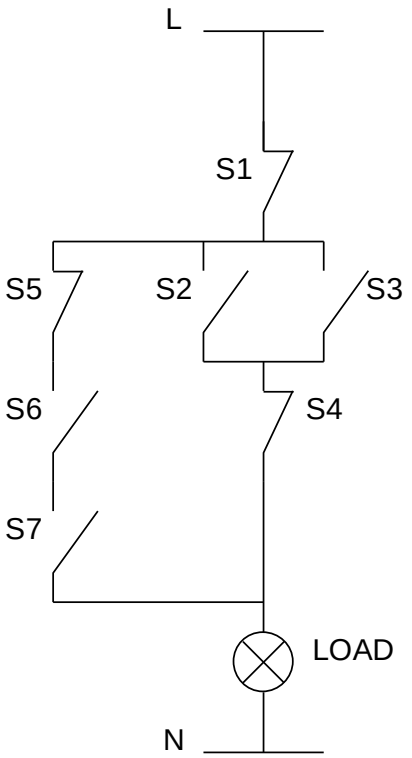
Electrical Circuit



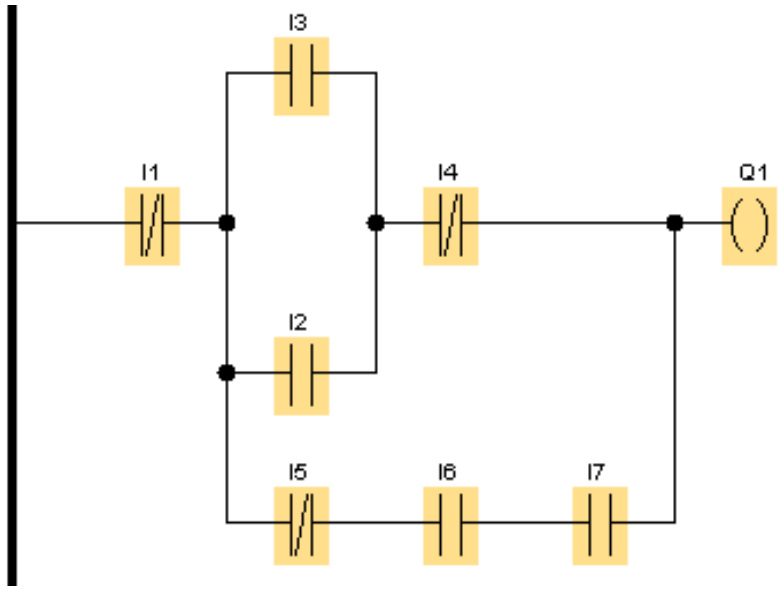
Ladder Diagram

Applications

Operating a load from different points.

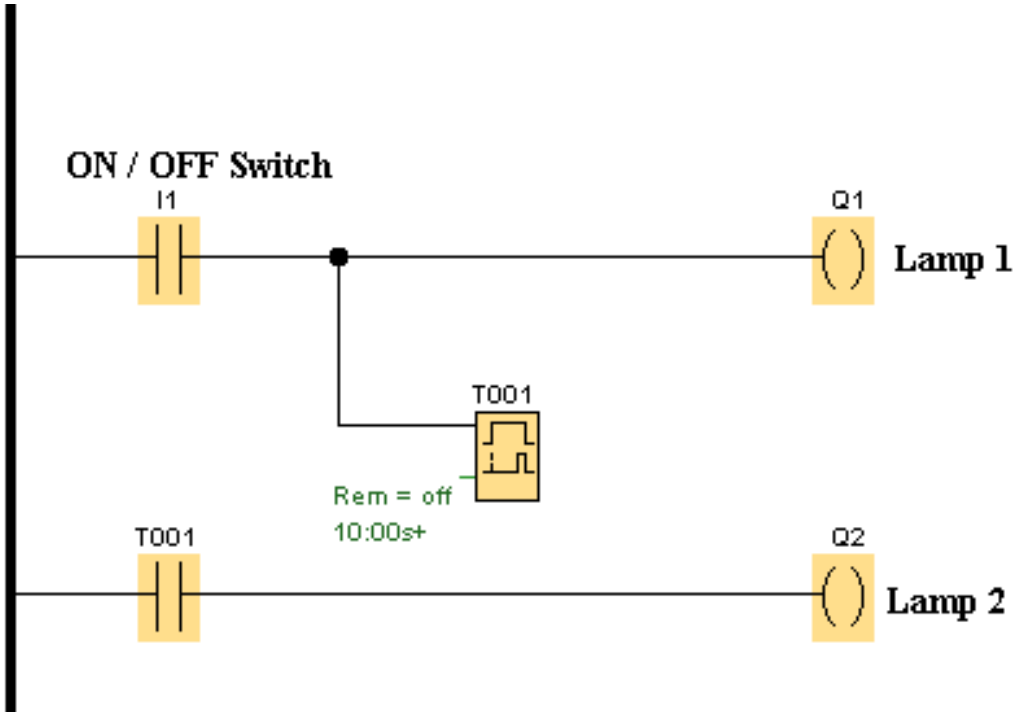


Electrical Circuit

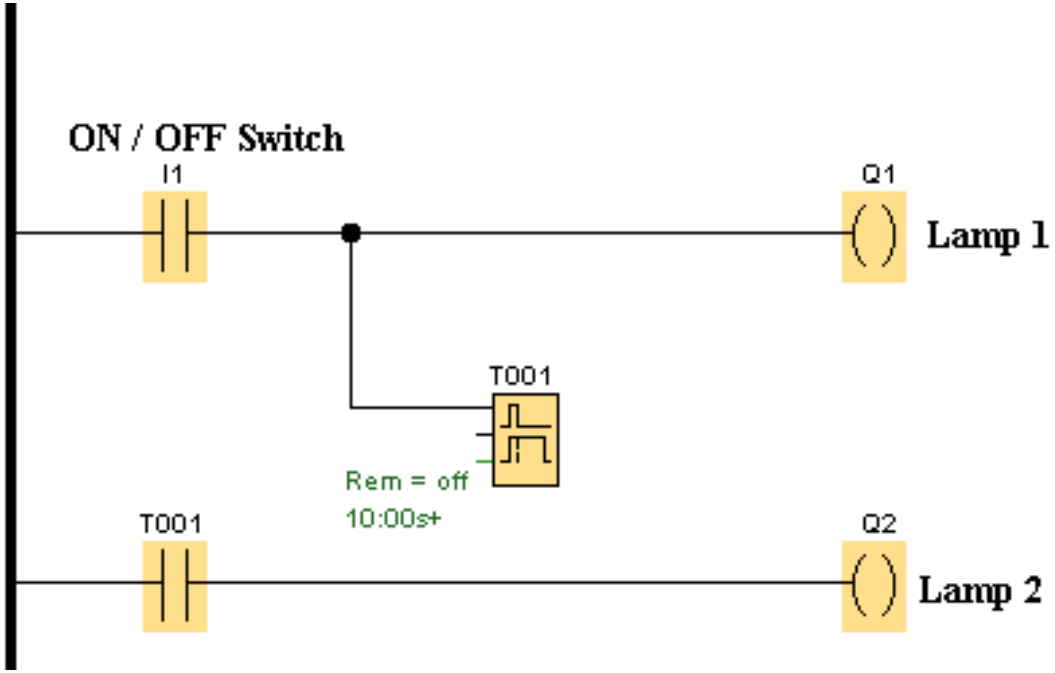


Ladder Diagram

On-Delay and Off Delay Timer Using Ladder Programming Language

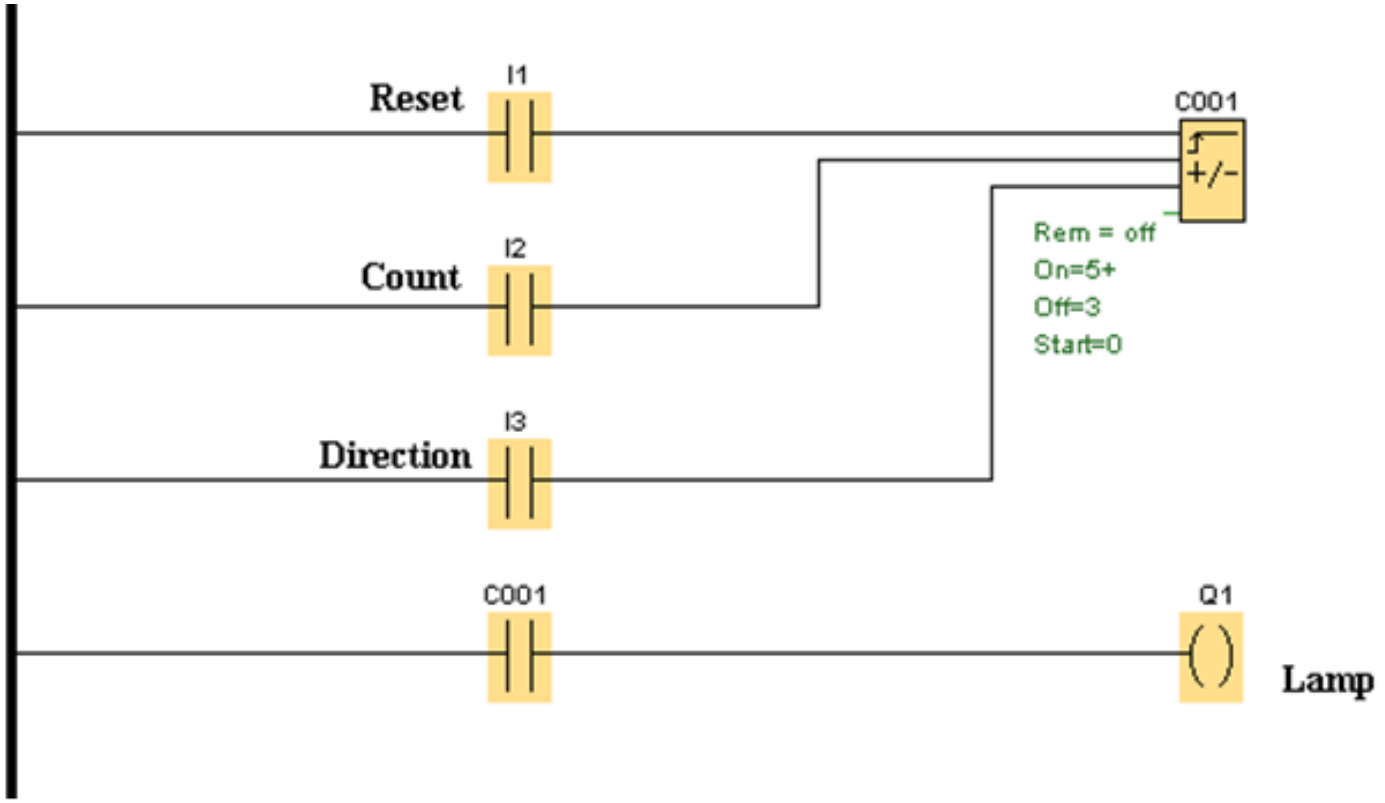


On-Delay Timer



Off-Delay Timer

Counters
Using Ladder Programming Language



Counters

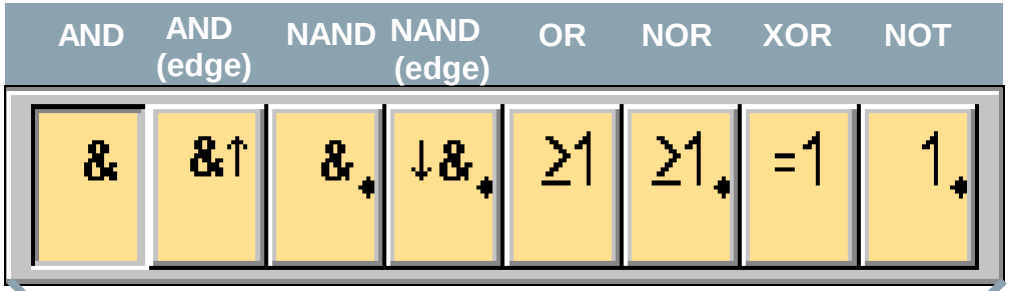
SIEMENS

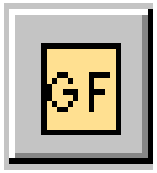
LOGO!

Week 4: Basic functions

Innovative Switching & Control

Basic functions





8 basic functions

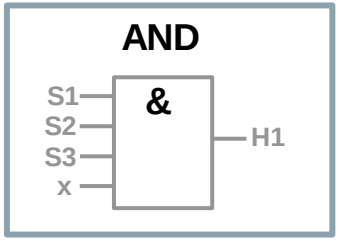
AND function

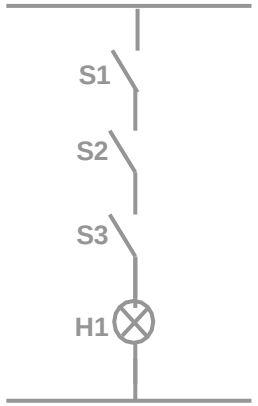
A look at the circuit diagram shows that the light H1 is only on when S1 and S2 and S3 are closed. Input and output states are dependent on each other.

The circuit to the right is called AND logic.

In words contact S1 and S2 and S3 have to be closed for the light to burn.

Symbol for this connection is 





Series circuit normally open contact

Output of the AND function is 1 only when all inputs are 1.
If one input pin of this block is not connected, the status is automatically 1.

Logic table for AND block:

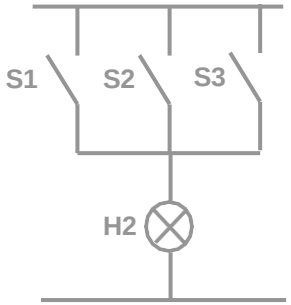
Input 1	Input 2	Input 3	Output
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

OR function

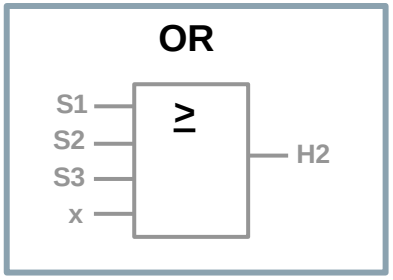
To turn the lamp H2 on, the contact S1 or S2 or S3 have to be closed. The dependence of output states from inputs states is called OR logic.

In words at least one of the contacts S1 or S2 or S3 have to be closed for the lamp H2 to light up.

Symbol for this connection is ≥1 .



Parallel circuit
normally open contact

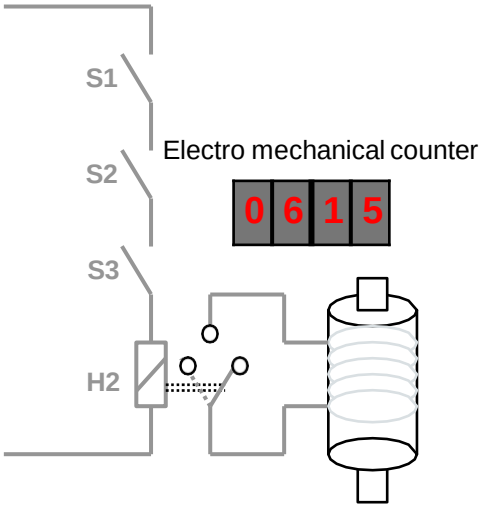


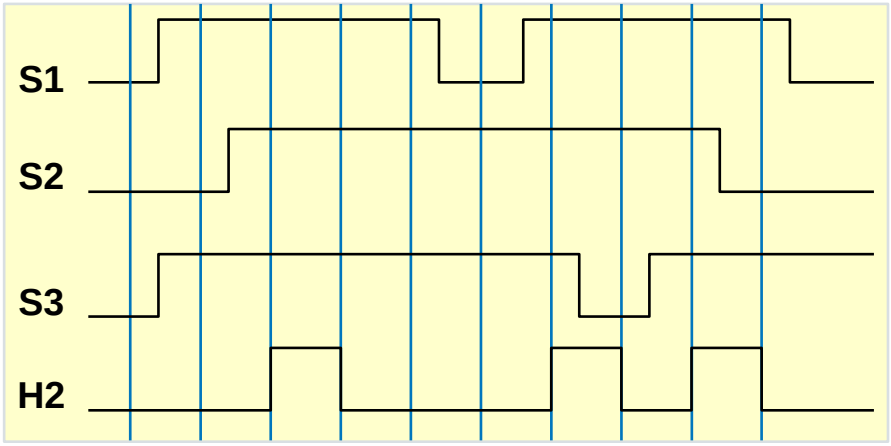
Output of the OR function is 1, when at least one input is 1.
If one input pin of this block is not connected, the status is automatically 0.

Logic table for OR block:

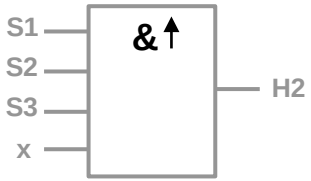
Input 1	Input 2	Input 3	Output
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

AND with edge triggering





AND with edge triggering



Output of AND with edge triggering is 1, only when all inputs are 1 and in the previous cycle at least one input was 0. If one input pin of this block is not connected, the status is automatically 1.

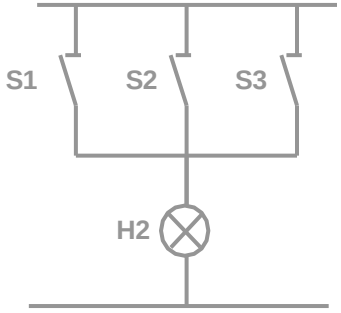
NAND (not-AND) function

A look at the circuit diagram shows that the light H2 is not on, only when all contacts are switched.
The circuit to the right is called NAND logic.

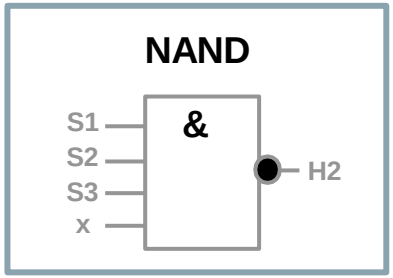
In words S1 and S2 and S3 have to be switched for the light H2 not to burn.

Symbol for this connection is 

.



Parallel circuit normally closed contact

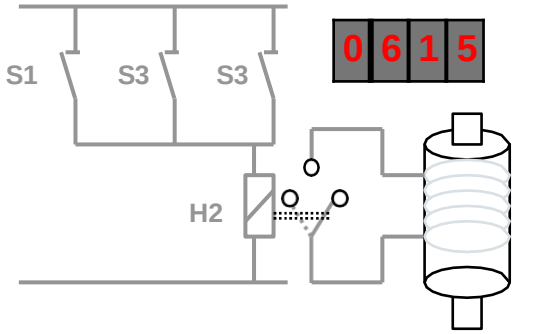


Output of NAND is 0, only when all inputs are 1.
If one input pin of this block is not connected, the status is automatically 1.

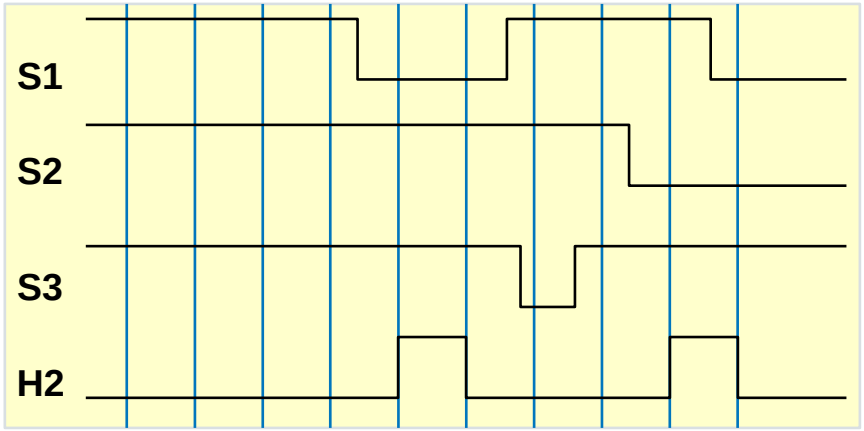
Logic table for NAND block:

Input 1	Input 2	Input 3	Output
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

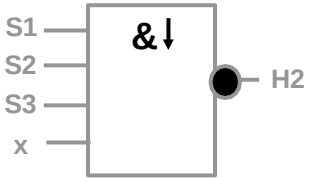
NAND (not-AND) with edge triggering



Electro mechanical counter



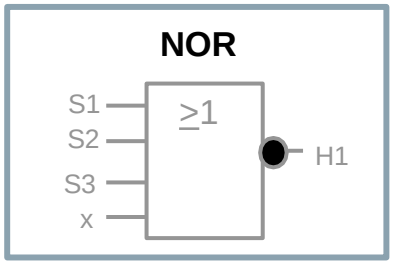
NAND with edge triggering

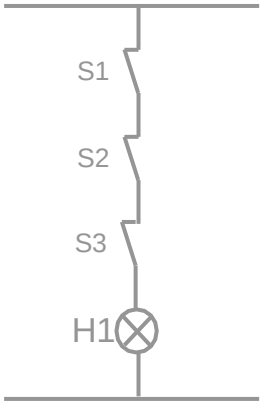


Output of NAND with edge triggering is 1, only when at least one input is 0 and in the previous cycle all inputs were 1.
If one input pin of this block is not connected, the status is automatically 1.

NOR (not-OR) function

A look at the circuit diagram shows that the light H1 is only on, when the normally closed contact S1 and S2 and S3 are not switched.
The circuit to the right is called NOR logic.
In words when S1 or S2 or S3 are switched, the light is not on.
Symbol for this connection is ≥1.





Series circuit normally closed contact

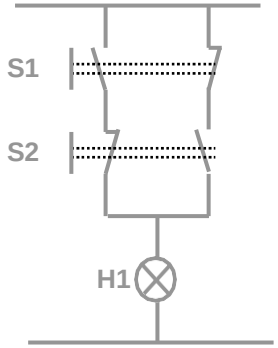
Output of NAND is 1, only when all inputs are 0. As soon as any input is switched (status 1), the output is switched off. If one input pin of this block is not connected, the status is automatically 0.

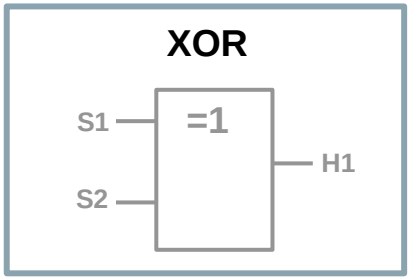
Logic table for NOR block:

Input 1	Input 2	Input 3	Output
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

XOR function

A look at the circuit diagram shows that the light H1 is only on, when only one of either S1 or S2 is switched.
This circuit is called XOR logic.
In words when either contact S1 or contact S2 are switched, the light is on.
Symbol for this connection is =1 .





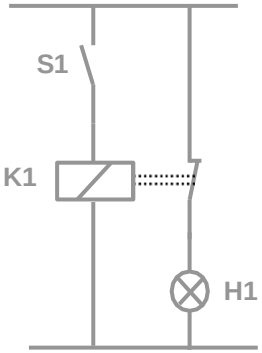
Output of XOR is 1, when inputs have different states.
If one input pin of this block is not connected, the status is automatically 0.

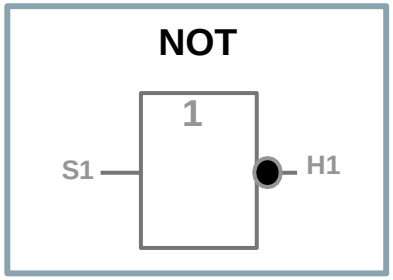
Logic table for XOR block:

Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	0

NOT function

A look at the circuit diagram shows that the light H1 is only on, when the switch S1 is not switched.
This circuit is called NOT logic.
Symbol for this connection is 1.





Output is 1, when the input is 0, i.e. NOT inverts the status at the input.
The advantage of NOT is for instance: You will not need a normally closed contact any more for LOGO!. You can use a normally open contact and change it with NOT to a normally closed contact.
If the input pin of this block is not connected, the status is automatically 1.

Logic table for NOT block:

Input 1	Output
0	1
1	0

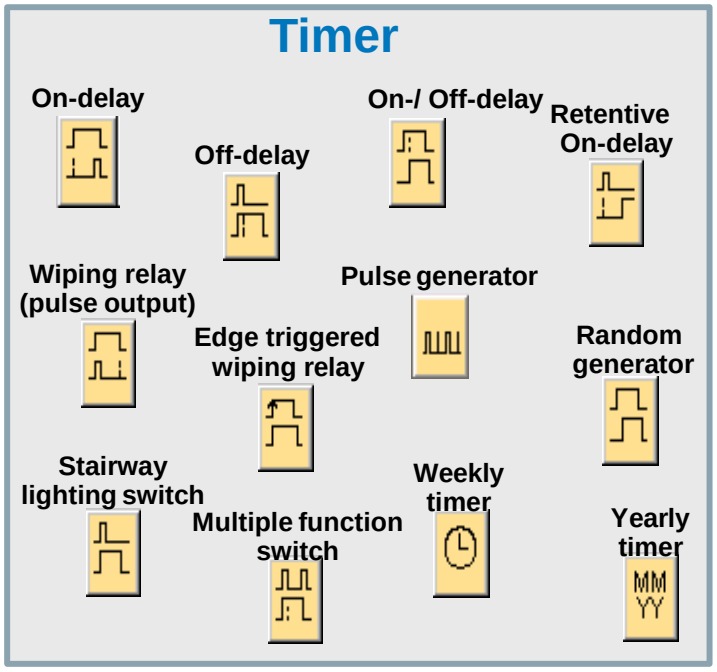
SIEMENS

LOGO!

Week 5: Timers

Innovative Switching & Control

Special functions - overview



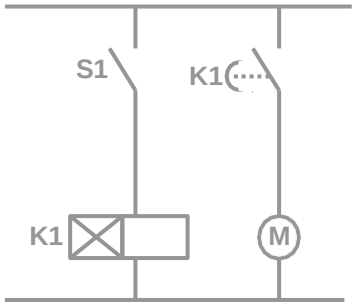
Timer – On-delay

A look at the circuit diagram shows that the motor only starts after expiry of the delay time.

This function is called On-delay.

In words the motor will be switch on with a programmed ON delay time.

Symbol for this function is  .



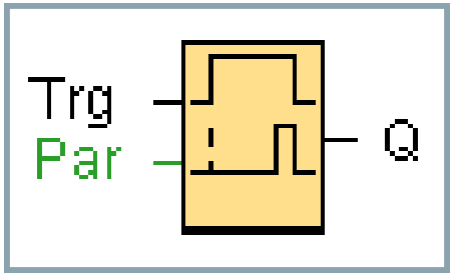
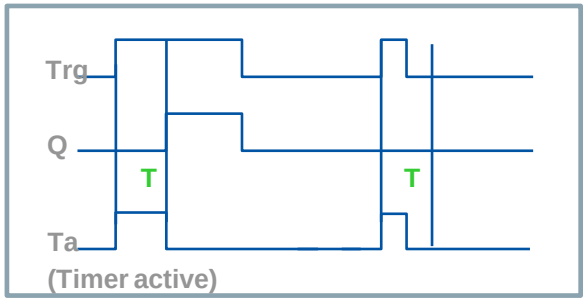


Diagram:



Description of the function:

With 0 to 1 transition of input Trg the timer starts. If the status of input Trg is 1 for long enough, the output is set to 1 on expiration of the time T. The output follows the input with on delay. The output is reset to 0 when the status at input Trg is 0.
If the status of input Trg changes to 0 before the time T has expired, the time is reset. The

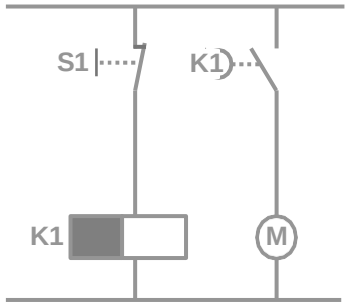
Timer – Off-delay

A look at the circuit diagram shows that the motor only stops after expiry of the delay time.

This function is called Off-delay.

In words the motor will be switch off with a programmed OFF delay time.

Symbol for this function is  .



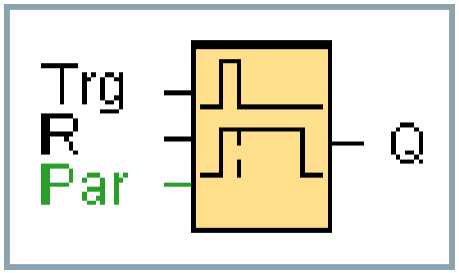
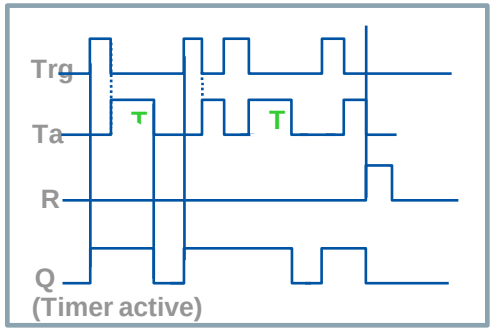


Diagram:



Description of the function:

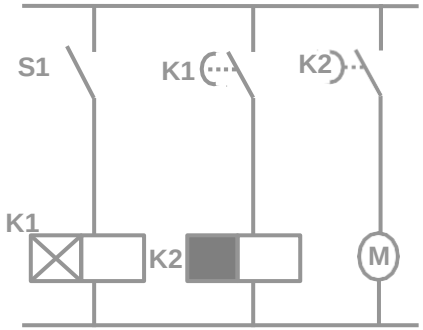
When the input Trg is 1, the output Q is switched instantaneously to 1. When the status of Trg changes from 1 to 0, the timer will be activated. The output remains set. When the timer reaches the configured value (Ta=T), output Q is reset to 0. When input Trg is switched on and off again, the time Ta restarts. Input R (Reset) is used to reset the time Ta and the output before Ta has expired.

Timer – On-/Off-delay

A look at the circuit diagram shows that:

- when S1 is closed, contact K1 closes with a delay time and the motor runs.
- when S1 is opened, contact K2 opens with a delay time and the motor stops.

This function is called On-/Off-delay. In words the motor is switched on and off with a programmed delay time.
Symbol for this function is  .



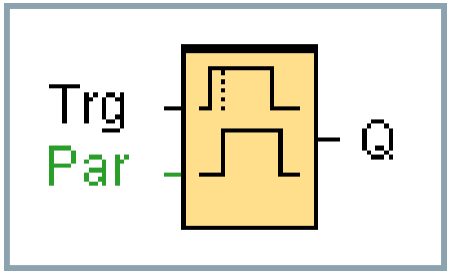
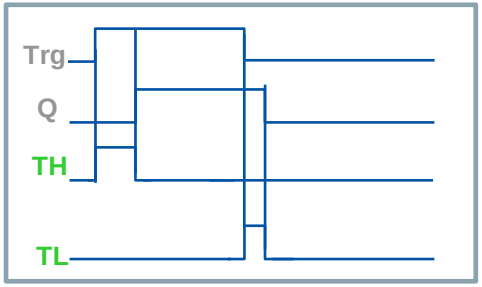


Diagram:



Description of the function:

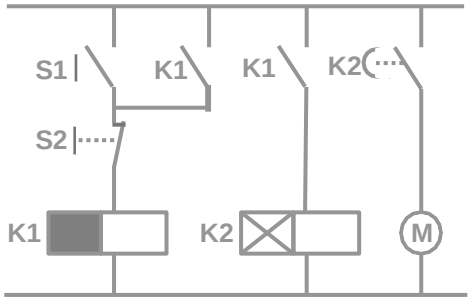
The time TH starts after a 0 to 1 transition at input Trg. If the status at input Trg is 1 for the duration of the time TH, the output is set to 1 on expiration of the time TH.
(the output follows the input on delayed). When the status at input returns to 0, TL starts. If the status at input Trg is 0 for the duration of time TL, the output is set to 0 on expiration of

Timer – Retentive On-delay

A look at the circuit diagram shows that the motor M starts delayed after pressing the pushbutton S1. Pushbutton S2 (n.c. contact) stops the motor again.

This function is called retentive On-delay.

Symbol for this connection is  .



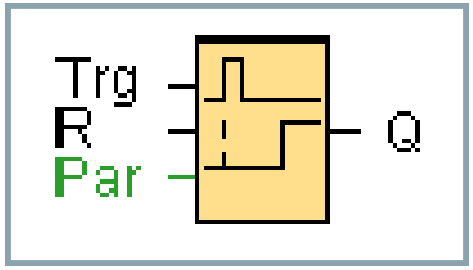
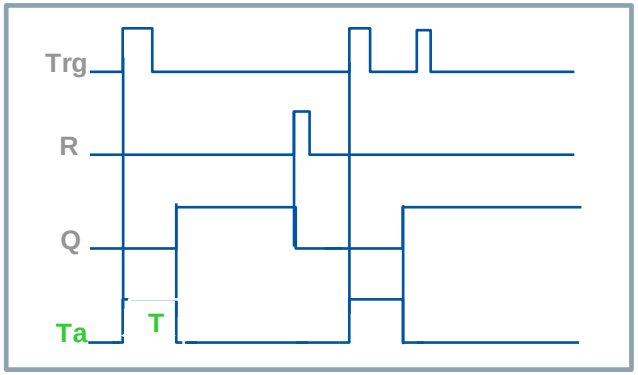


Diagram:



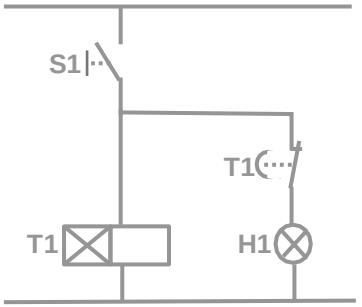
Description of the function:

The current time Ta starts with a 0 to 1 transition at input Trg. Output Q is set to 1 when Ta reaches the time T. The output Q is only reset to 0 when the status at input R is 1. Further

Timer – Wiping relay (pulse output)

A look at the circuit diagram shows that the light H1 is only on, when the switch S1 is closed, but only as long as the set time at timer T1.

Symbol for this connection is  .



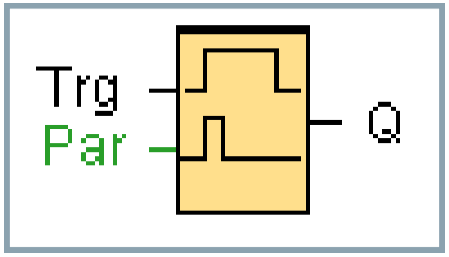
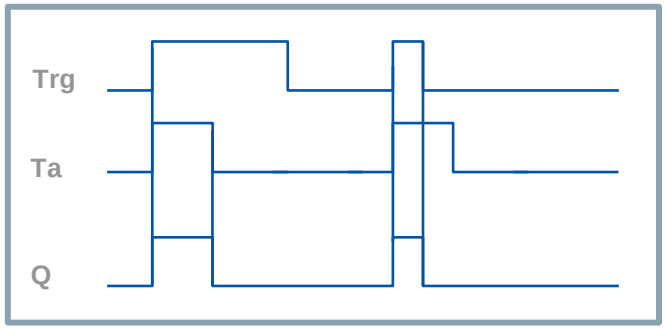


Diagram:



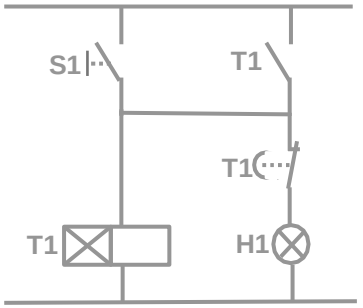
Description of the function:

When the input Trg is set to 1, the output Q is immediately switched to 1. The current time Ta starts in LOGO! at the same time and the output remains set. When Ta reaches the value specified in T (Ta=T), the status of output Q is reset to 0 (pulse output). On input Trg transition from 1 to 0 before the specified time has expired, the output follows immediately

Timer – Edge triggered wiping relay

A look at the circuit diagram shows that the light H1 remains on for the time specified on the timer T1 when the switch S1 is closed.

Symbol for this connection is  .



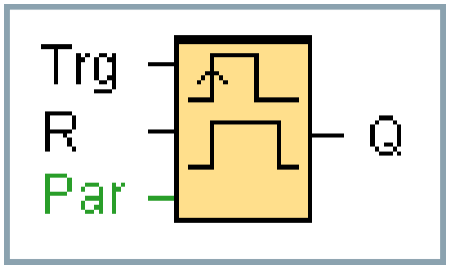
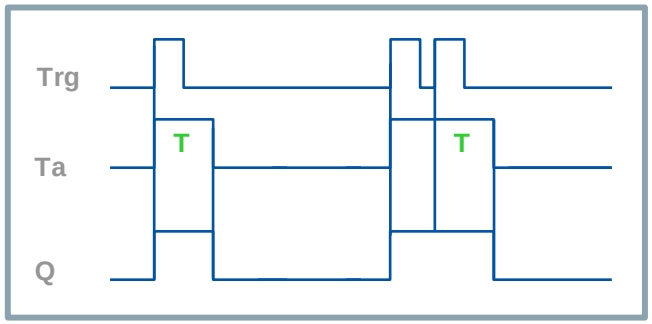


Diagram:



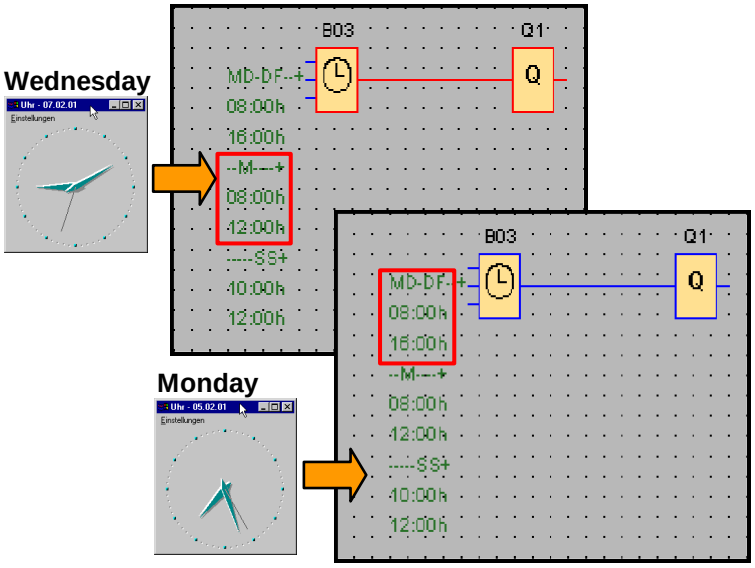
Description of the function:

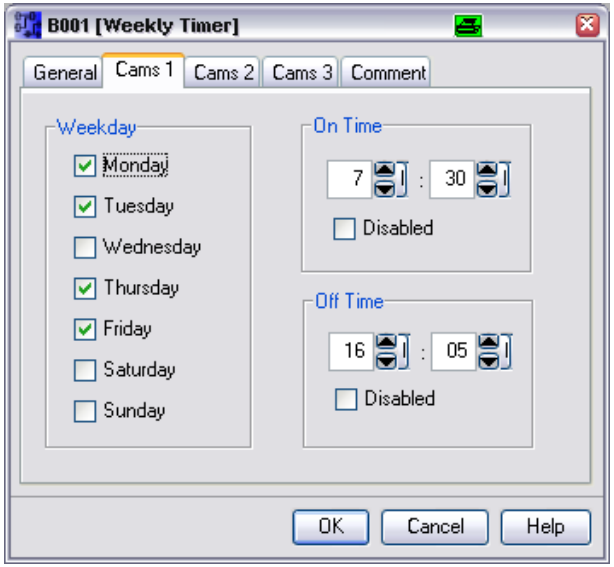
The output status is switched to 1 after the input Trg is set to 1. Time Ta is started at the same time. After Ta has reached the value specified in T (Ta=T) the output Q status is reset to 0 (pulse output). If input Trg changes again from 0 to 1 (retriggering) before the specified time has expired, the time Ta is reset and the output remains switched on.

Timer – Weekly timer

The output is controlled via a specified on–/ off–date. The function supports any combination of weekdays. You select the active weekdays by deselecting the inactive days.

	Mon	Tue	Wed	Thurs	Fri	Sa	So	On:	Off
Cam 1	X	X		X	X			07 : 30	16 05
Cam 2			X					08 : 00	12 00
Cam 3						X	X	10 00	12 30





Description of the function:

Every weekly timer has three cams. You can configure a time hysteresis for each cam. Within the cam setting you specify the on/off times.

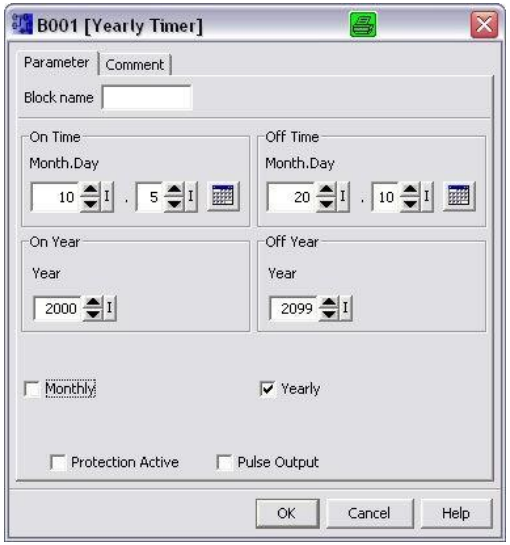
If you enable “pulse output”, the timer will be reset after one cycle. “Pulse output” applies to all three cams.

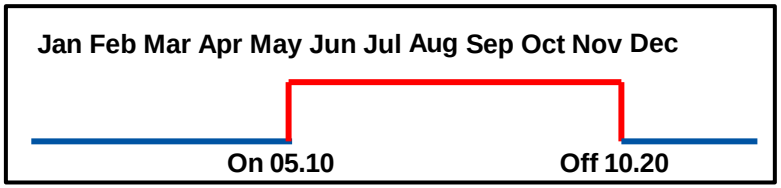
Timer – Yearly timer

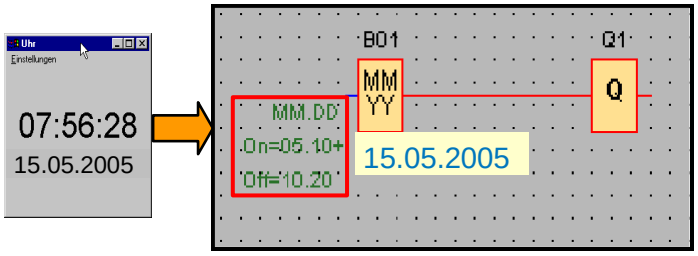
Description of the function:

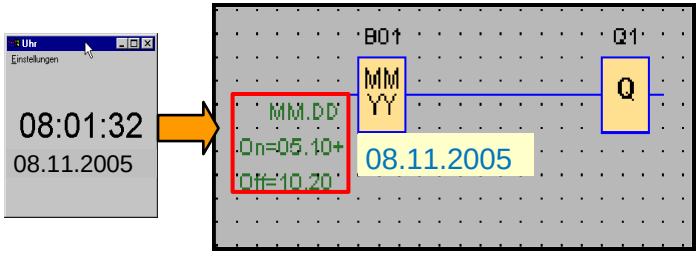
Every yearly timer has an on- and off-timer. At the specified on-time the yearly timer switches on the output. At the specified off–time the yearly timer switches off the output. The off–date specifies the day/year on which the output is reset to 0 again.

By selecting the option field
- "Monthly", the timer switches on or off at a specified day each month.
- "Yearly", the timer switches on or off each year at a specified month and day.
- "Pulse Output", the timer output switches on at the specified On Time for one cycle. Then it is reset.









Timer – Asynchronous pulse generator

The pulse profile of the output can be customized via pulse/ pause ratio.
Symbol for this function is  .

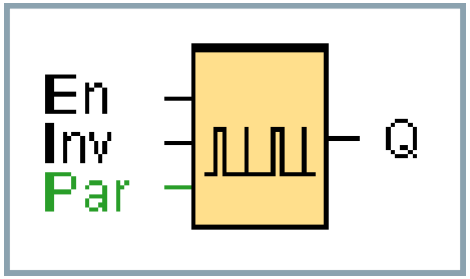
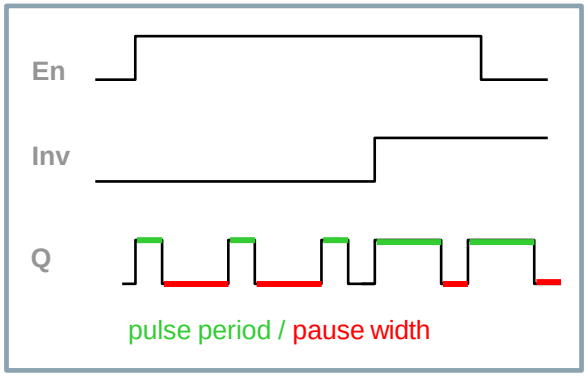


Diagram:



Description of the function:

In the parameters you can adjust the pulse period and the pause width. With input INV you can also invert the output. You can customized the time period in seconds, minutes or hours. The time basis of both parameters can be set independently. The input block INV only negates the output if it is enabled via EN.

Timer – Random generator

With a random generator the output is switched on and off again within a specified time.

Symbol for this function is  **.**

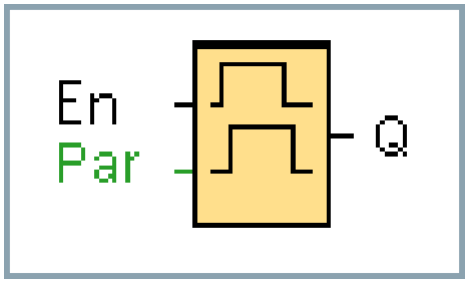
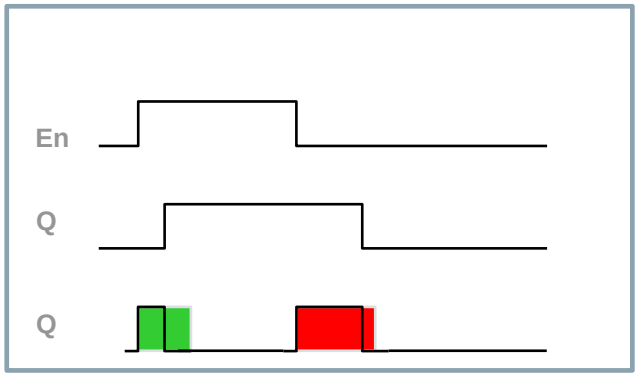


Diagram:



max. ON delay / max. OFF delay

Description of the function:

With a 0 to 1 transition of the input En a random time e.g. between 0 and 10 seconds is started. The output is set to 1 on expiration of the on delay time, if the input En is 1 at least for the duration of the on delay time. The time is reset if the status at input En returns to 0 before the on delay time has expired. When the input En changes from 1 to 0, a random off delay time between 0 and e.g. 15 seconds is started. The time is reset if the status at input En returns to 1 before the on delay time has expired.

Timer – Stairway lighting switch

The input pulse (edge control) starts a specified time. The output is reset on expiration of this time. Prior to the expiration of this time (e.g. 15 s) an off pre–warning is generated.

Symbol for this function is  .

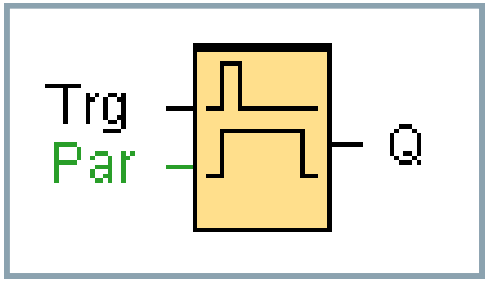
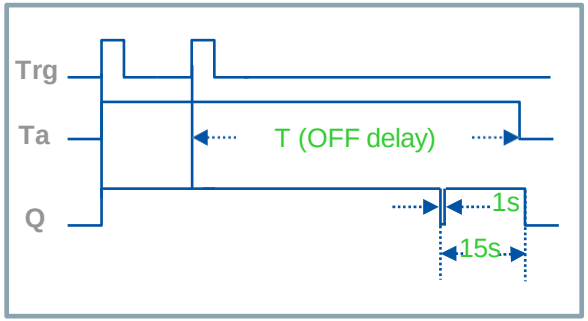


Diagram:



Description of the function:

With a 0 to 1 transition at input Trg, the current time starts and the output Q is set to 1. E.g. 15 s before Ta reaches the time T, the output Q is reset to 0 for a time of 1 s (configurable time). When Ta reaches the time T, the output Q is reset to 0. When input Trg is switched on

Timer – Multiple function switch

Switch with two different functions:

- Pulse switch with off delay
- Switch (continuous lighting)

Symbol for this function is  .

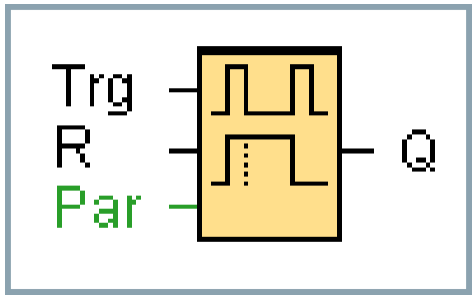
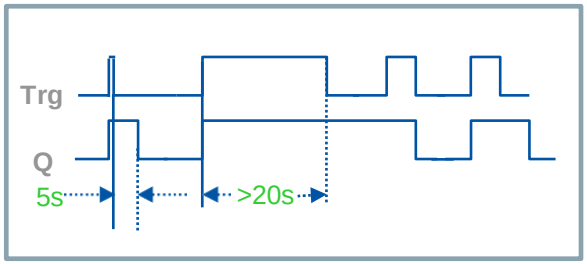


Diagram:



Description of the function:

The output Q is set to 1 with a 0 to 1 transition of the status at input Trg. When the input Trg changes to 0 before expiration of the continuous lighting time, the output resets to 0 with an off delay of e.g. 5 seconds. With a 0 to 1 transition of the status at input Trg and if the status '1' is set at least for the duration of e.g. 20 seconds, the continuous lighting function is enabled and the output Q is switched on continuously. If the input Trg is switched once again from 0 to 1 and again to

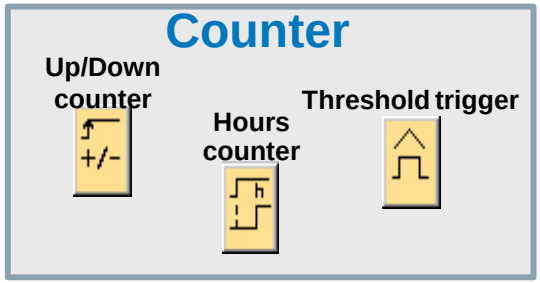
SIEMENS

LOGO!

Week 6: Counters

Innovative Switching & Control

Special functions - overview



Counter – Up and Down counter

A look at the circuit diagram shows that the switch S1 triggers the counter pulses. Switch S2 determines whether the counter increases or decreases. When the counter status reaches a value >= 5, the light switches on.

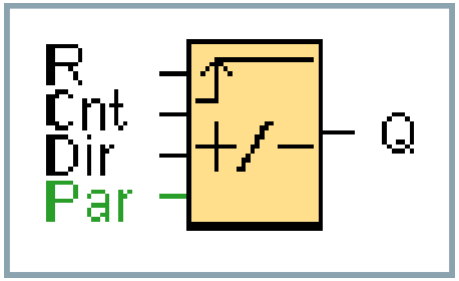
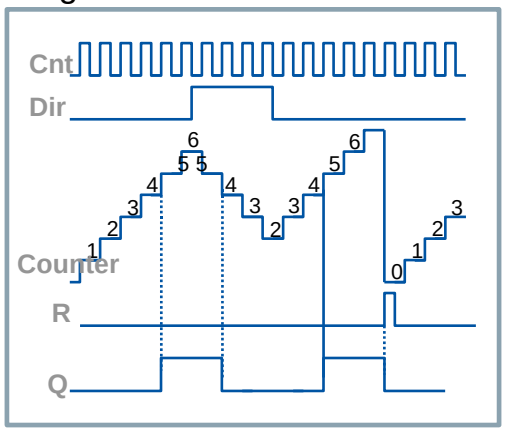
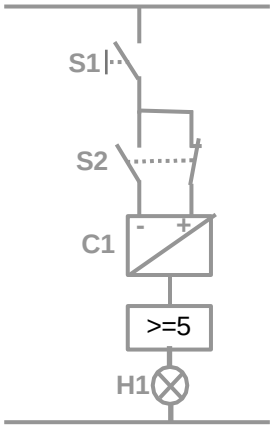


Diagram:



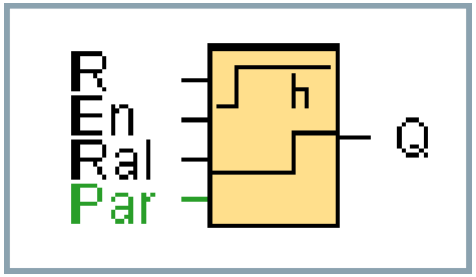


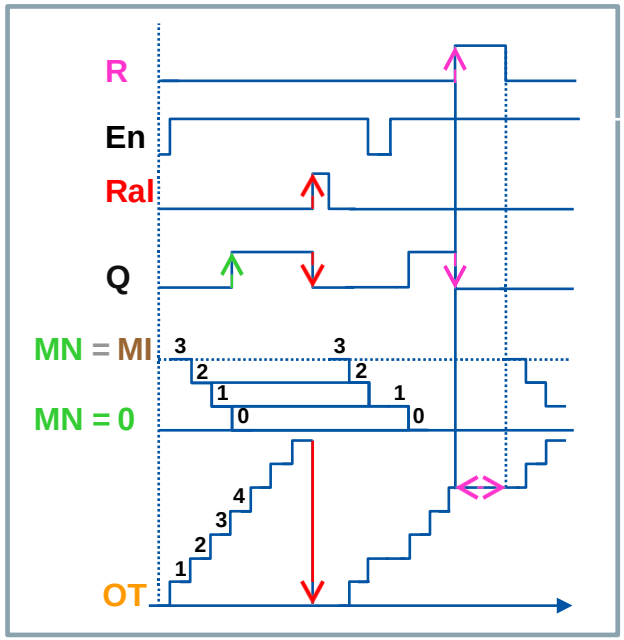
Description of the function:

With every positive edge at input Cnt the internal counter increments (Dir = 0) or decrements (Dir = 1) by one count. Output Q is set to 1 when the internal value is greater than or equal to the value specified in Par. You can use reset input R to reset the output and the internal count value to the start value. When R=1, the output is 0 and the pulses at input Cnt are not counted.

If you set a "Start Value" the counter begins to count either up or down from this value.

Counter – Hours counter





Description of the function:

The hours counter monitors the input En. As long as the status of this input is 1, LOGO! determines the expired time OT and the time–to–go MN. LOGO! displays the times in parameter assignment mode. Output Q is set to 1 when the time–to–go MN = 0. Use input R to reset output Q and time–to–go counter to the specified value MI. The internal counter OT continues the count. Use input Ral to reset output Q and the time–to–go counter MN to the specified value MI. The internal counter OT is reset to 0.

Counter – Threshold trigger

The output is switched on and off, depending on two specified frequencies.
Symbol for this function is  .

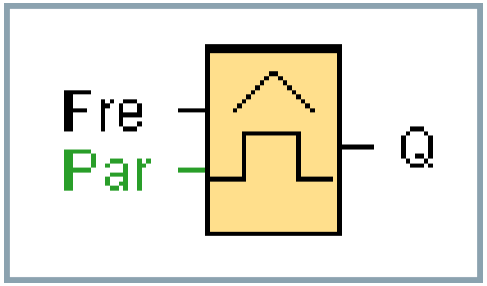
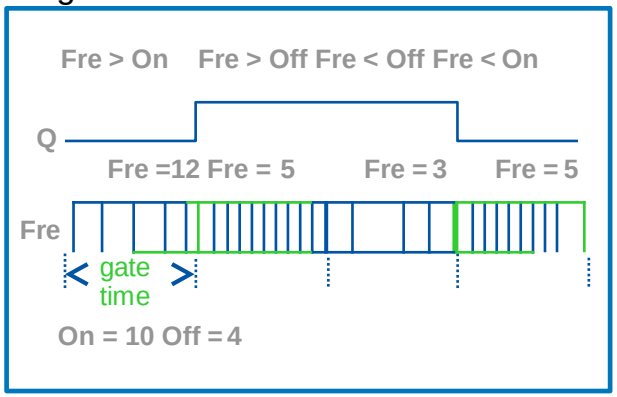


Diagram:



Description of the function:

The threshold trigger measures the signals at input Fre. The pulses are captured across a specified period (gate time).
Output Q is switched on, if the value measured within the gate time is higher than the ON threshold. Q is switched off again when the threshold drops below OFF.

On : is the ON threshold. It may be between 0000 and 9999.

Off : is the OFF threshold. It may be between 0000 and 9999.

Gate time: is the time interval during which the pulses at Fre are measured.
It may be 00.05s and 99.99s.

الدرس الأول

عملية البرمجة اليدوية لجهاز (LOGO!)

عندما نقوم بربط (LOGO !) لأول مرة إلى مصدر القدرة الكهربائية تكون ذاكرته خالية من البرنامج تظهر لنا رسالة التالية . لايوجد برنامج أضغط على زر Esc

سوف تظهر لنا على شاشة (LOGO !) أربعة خيارات نستطيع الانتقال بين هذه الخيارات بواسطة الأسهم الأعلى والأسفل (▽△) الموجودة على جهاز (! LOGO) والنقطتين تشير إلى قائمة

(Program ..) قائمة البرنامج

(Card ..) قائمة أل(Transform)

(Setup ..) قائمة الأعداد

(Start) خيار تشغيل البرنامج في حالة وجود برنامج في (LOGO!)

وعند اختيار الأمر (Program..) نكبس على زر (OK)

سوف تظهر لنا على شاشة (LOGO!) أربعة خيارات:

(Edit ..) قائمة تحرير

(Clear Prg) مسح البرنامج

(Password) وضع كلمة مرور أو تغيير كلمة المرور

(Msg Config) أعداد الرسائل

وعند اختيار الأمر (Edit ..) نضغط على زر (OK)

سوف تظهر لنا على شاشة (LOGO!) الخيارات التالية:

(Edit Prg) تحرير البرنامج كتابة البرنامج

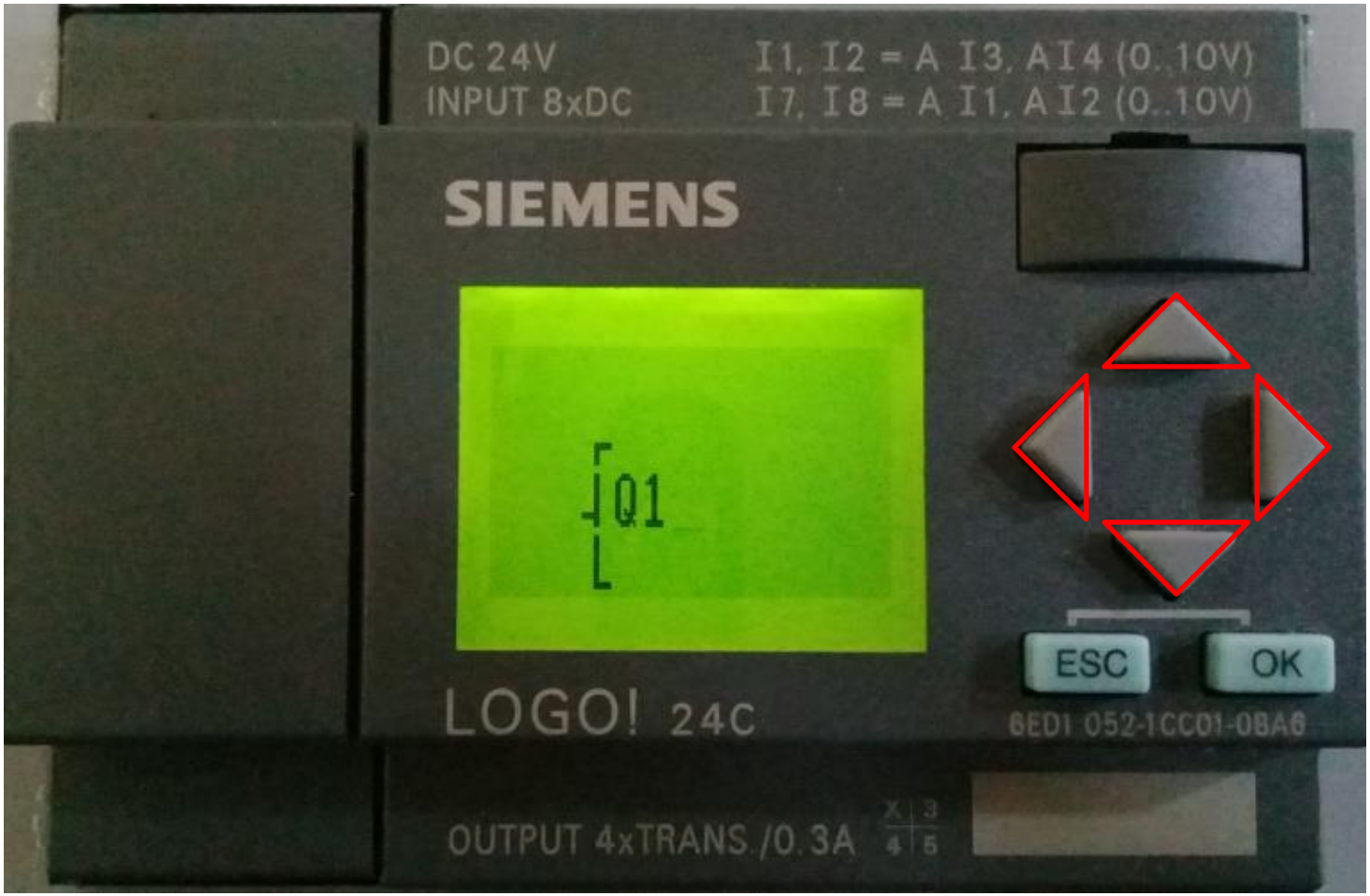
(Edit Name) كتابة اسم البرنامج

(AQ)إعداد أل(Analog Output)

(? Memory) وصف أل (Memory)

وعند اختيار الأمر (Edit Prg) نكبس على زر (OK)

ننتقل إلى كتابة البرنامج عملية كتابة البرنامج يدويا في (LOGO!) تكون من الإخراج إلى الإدخال نستطيع تغيير الإخراج بواسطة الأسهم الأعلى والأسفل في نفس المجموعة والانتقال إلى المجاميع بواسطة الأسهم اليمين واليسار والمجاميع التي لدينا .

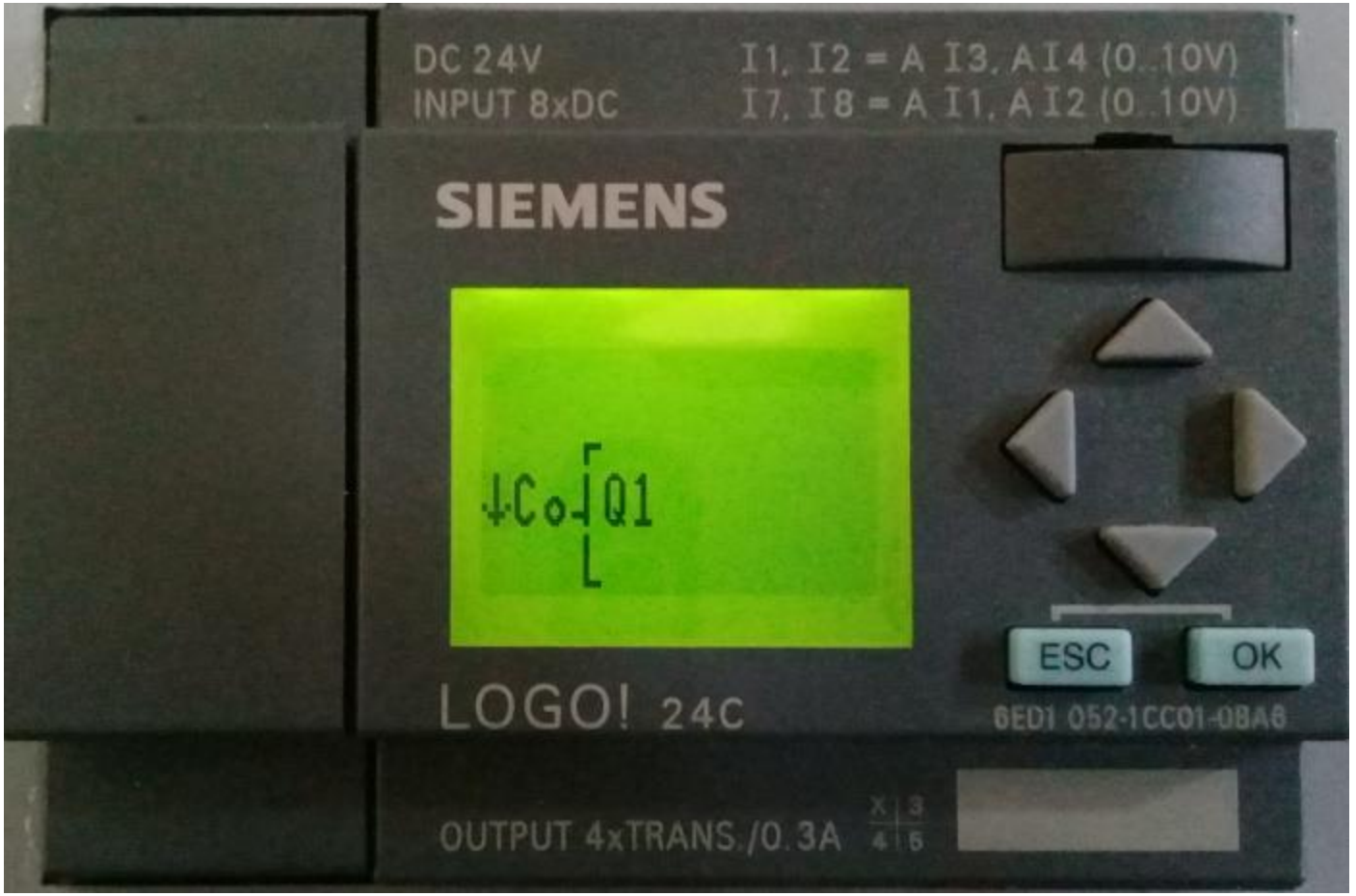


Q : Digital Out put
M : Digital
AQ : Analog Out
put
AM : Analog flg
X : إشارة الإهمال

عند تثبيت على الخيار (Q1) نكبس على زر (OK)

فينتقل المؤشر إلى أول إدخال ولدينا الاحتمالات التالية:

الإشارات : (Constant) (Co)



الدوال الرئيسية : (General Function) (GF)

الدوال الخاصة : (Special Function) (SF)

فنختار (General Function) (GF) نضغط زر (OK)

فتظهر لنا أول دالة (AND) نستطيع تغيير الدوال بواسطة الأسهم الأسفل والأعلى وعند اختيار الدالة نكبس على زر (OK)

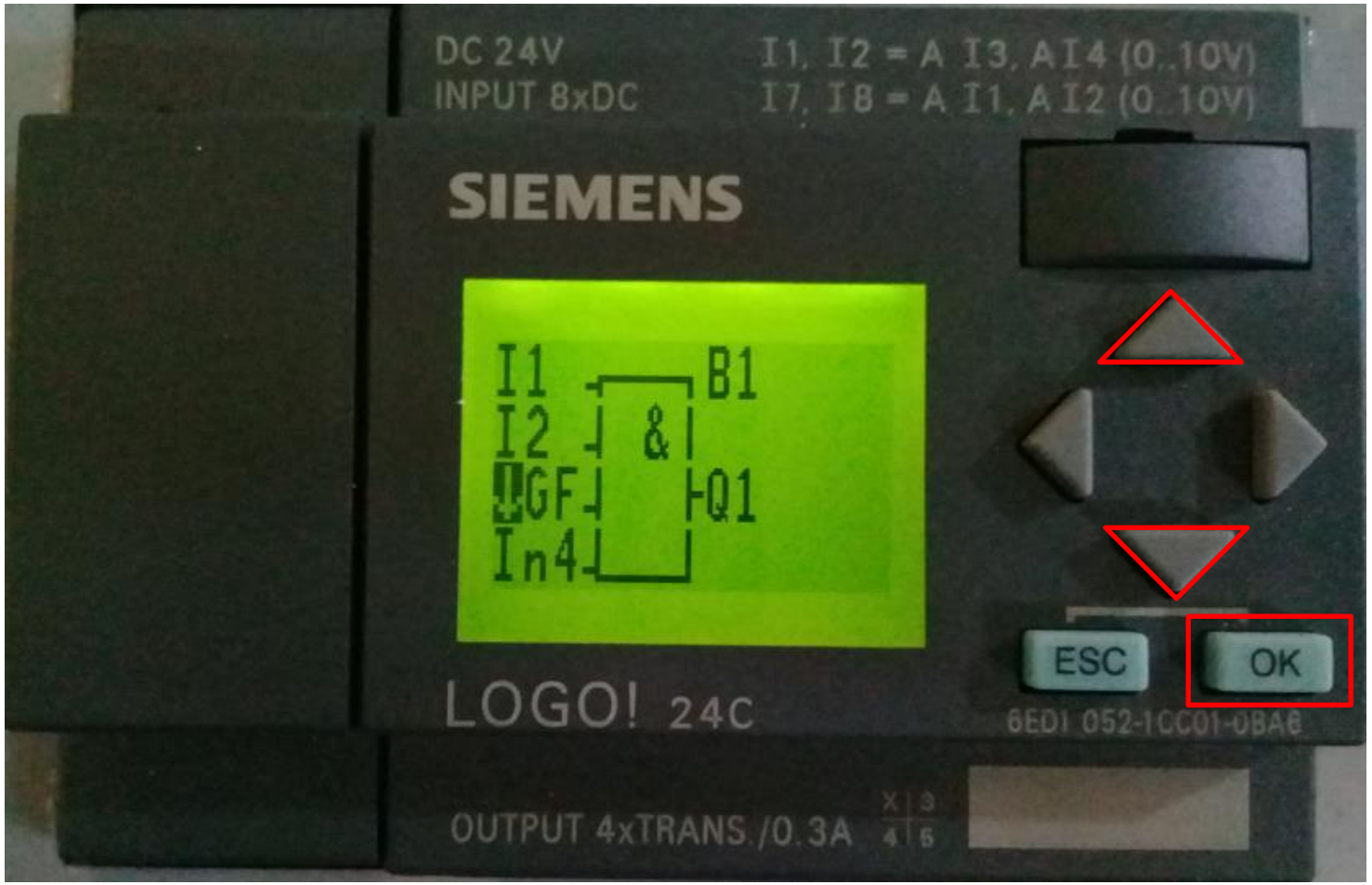
فينتقل المؤشر إلى الإدخال الأول .فترتبط بوابة (AND) مع الإدخال (Q1). فنضغط على زر (OK)

فيظهر لنا (Co) ويمكن اختيار الإشارات الحقيقية والبرمجية كإدخال لبوابة (AND) كأن يكون الأسهم (C) أو أزرار الشاشة (F1) أو إشارات الإهمال (x) أو إشارات الحالة (hi)(ho) وعند اختيار نوع الإدخال نكبس على زر (OK)

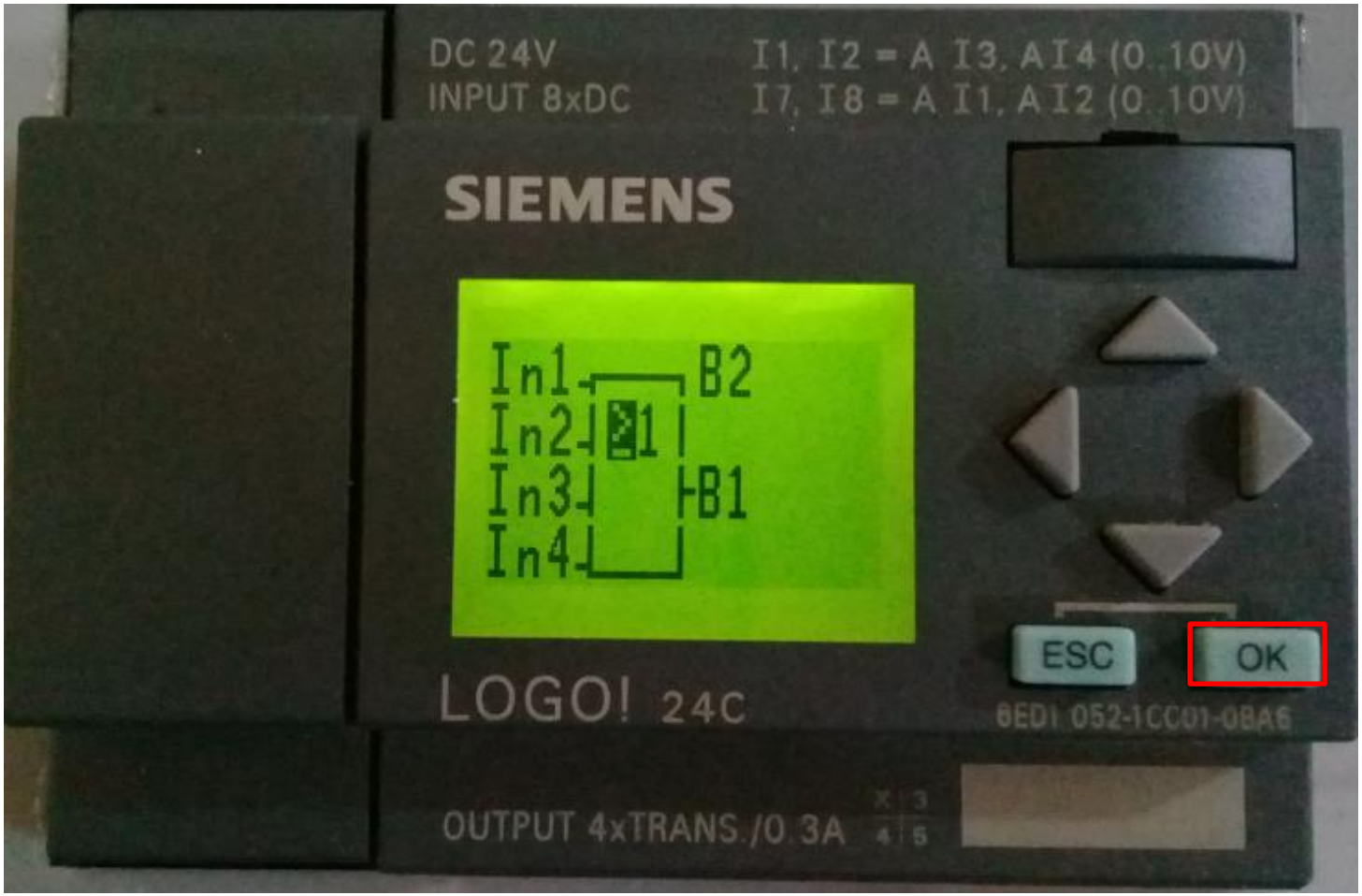
فيتم تثبيت الإدخال الأول (I1) ويمكن أخيار رقم الإدخال عن طريق الأسهم الأعلى والأسفل (▽ △) وعند الانتهاء من اختيار رقم الإدخال نضغط على زر(OK)

وعند ربط بوابة مع أخرى نضع المؤشر على الإدخال الثالث ونضغط (OK)
فيظهر لنا (Co) وبواسطة الأسهم الأسفل والأعلى نضغط على زر (OK)

وعند ربط بوابة مع أخرى نضع المؤشر على أي إدخال ونكبس (OK) فيظهر لنا (Co) وبواسطة الأسهم الأسفل والأعلى (▽△) نختار (GF) فنضغط على زر (OK)



فتظهر لنا البلوك الثاني (B2) والبوابة الثانية التي تم اختيارها هي بوابة (OR) فنضغط على (OK)



وبنفس الطريقة التي تم اختيار الادخالين (I1,I2) يتم اختيار الادخالين (I3,I4) وبعد ذلك نضغط على زر (OK)

وعند الانتهاء من برمجة البوابات وحسب الدائرة المطلوب تطبيقها نضغط على زر (ESC)

وعند الأكمل من البرمجة يتم الخروج من برمجة البرنامج والعودة إلى القائمة الرئيسية عن طريق الكبس المتكرر على زر أل (Esc) ومن القائمة الرئيسية نختار الأمر (Start) فنكبس على زر (OK) فيتم تفعيل البرنامج.

عند الانتهاء من اختيار الأمر (Start) وعند الكبس على زر (OK) تظهر لنا على شاشة (LOGO!) اليوم والوقت والتاريخ وبذلك تم خزن البرنامج في (LOGO!) ويتم تشغيل الدائرة عن طريق المفاتيح والمتحسسات الموجودة في الإدخال وبذلك تتم عملية البرمجة اليدوية للجهاز.

بسم الله الرحمن الرحيم

الدرس الثاني
كيفية عمل كلمة مرور للبرنامج

عند الانتهاء من كتابة البرنامج نختار الآمر(.. Program) ثم نكبس على الزر (OK)

فتظهر لنا القائمة التالية فنقوم بنزال السهم (>) بواسطة الاشفتات الأعلى والأسفل (△ ▽) إلى الأمر (Password) فنضغط على زر (OK)

فتظهر لنا القائمة التالية:

Old : الاسم القديم إذا كان مخزون سابقا

New : الاسم الجديد الذي نقوم بكتابته

لوضع كلمة مرور جديدة للبرنامج ونقوم بتغير الاحرف بوسطة الأسهم (▽ △) الأعلى والأسفل والآن قمنا بكتابة كلمة (PLC) وعند الانتهاء من كتابة الكلمة نضغط على زر (OK) وبذلك يتم خزن كلمة مرور للبرنامج.

عند القيام بفتح البرنامج بعدما تم وضع كلمة مرور له نضع المؤشر على (>)على الأمر (Edit..) ثم نضغط على زر (OK)

فيطلب منا جهاز (LOGO !) كلمة المرور التي تم خزنها.فنكتب الكلمة وبذلك يتم الولوج إلى البرنامج المخزون .