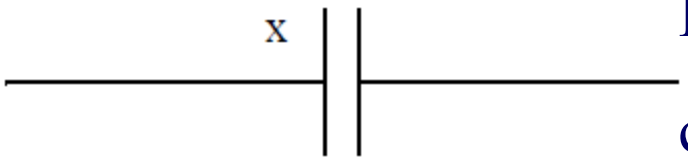
Lecture 4

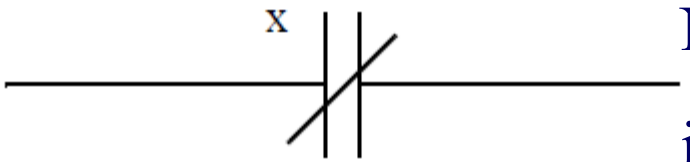
PLC programming

Ladder Logic Inputs

PLC inputs are easily represented in ladder logic. There are two types of inputs shown below. They are normally open and normally closed inputs.



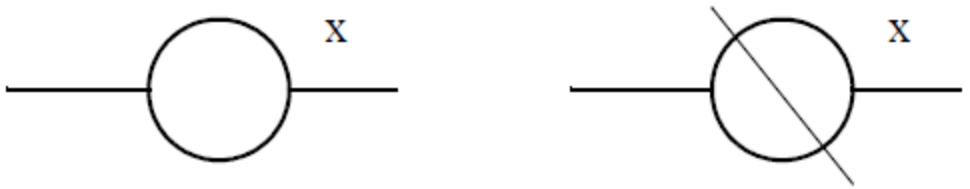
Normally open, an active input x will close the contact and allow power to flow.



Normally closed, power flows when the input x is not open.

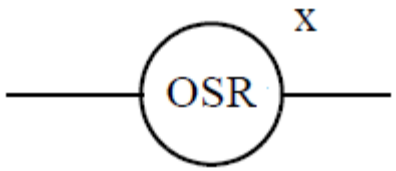
Ladder Logic Outputs

In ladder logic there are multiple types of outputs, but these are not consistently available on all PLCs. Some of the outputs will be externally connected to devices outside the PLC, but it is also possible to use internal memory locations in the PLC. Types of outputs are shown below



1. The first is a normal output, when energized the output will turn on, and energize an output. The circle with a diagonal line through is a normally on output. When energized the output will turn off. This type of output is not available on all PLC types.

2. OSR (One Shot Rise) When initially energized, the instruction will turn on for one scan, but then be off for all scans after, until it is turned off. An input transition on will cause the output x to go on for one scan (this is also known as a one shot relay)



Note: Outputs are also commonly shown using parentheses -( )- instead of the circle. This is because many of the programming systems are text based and circles cannot be drawn.

3. The L (latch) and U (unlatch) instructions can be used to lock outputs on. When an L output is energized the output will turn on indefinitely, even when the output coil is de-energized. The output can only be turned off using a U output.

When the L coil is energized, x will be toggled on, it will stay on until the U coil is energized. This is like a flip-flop and stays set even when the PLC is turned off.

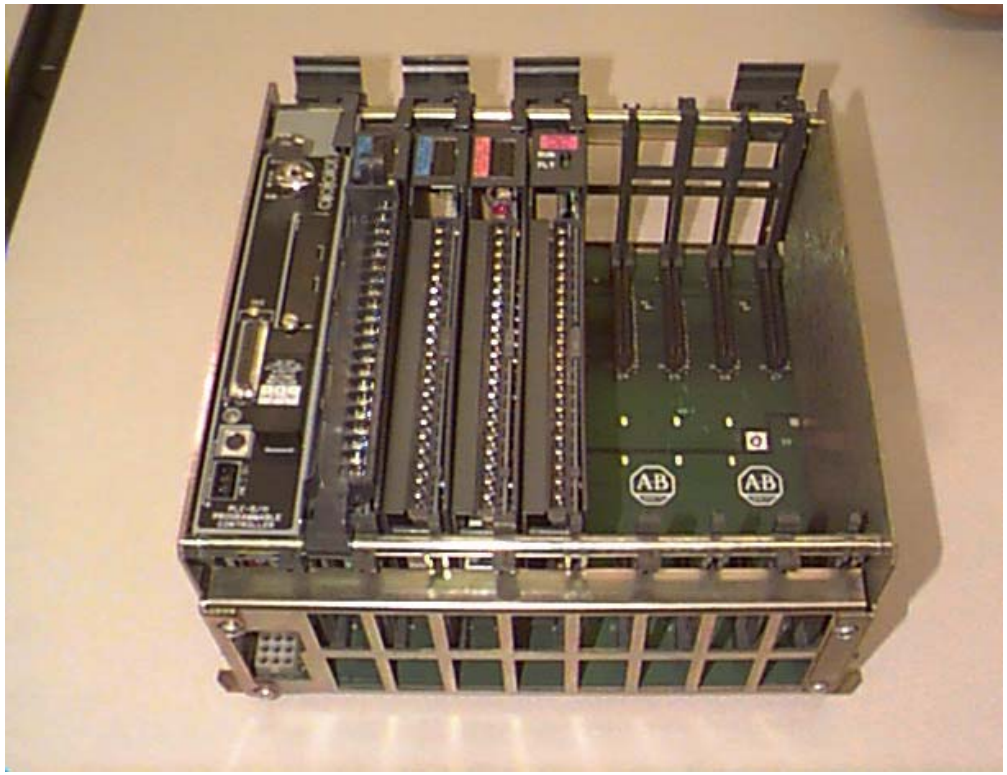
PLC HARDWARE

- Many PLC configurations are available, even from a single vendor. But, in each of these, there are common components and concepts. The most essential components are:
- Power Supply - This can be built into the PLC or be an external unit. Common voltage levels required by the PLC (with and without the power supply) are 24Vdc, 120Vac, 220Vac.
- CPU (Central Processing Unit) - This is a computer where ladder logic is stored and processed.

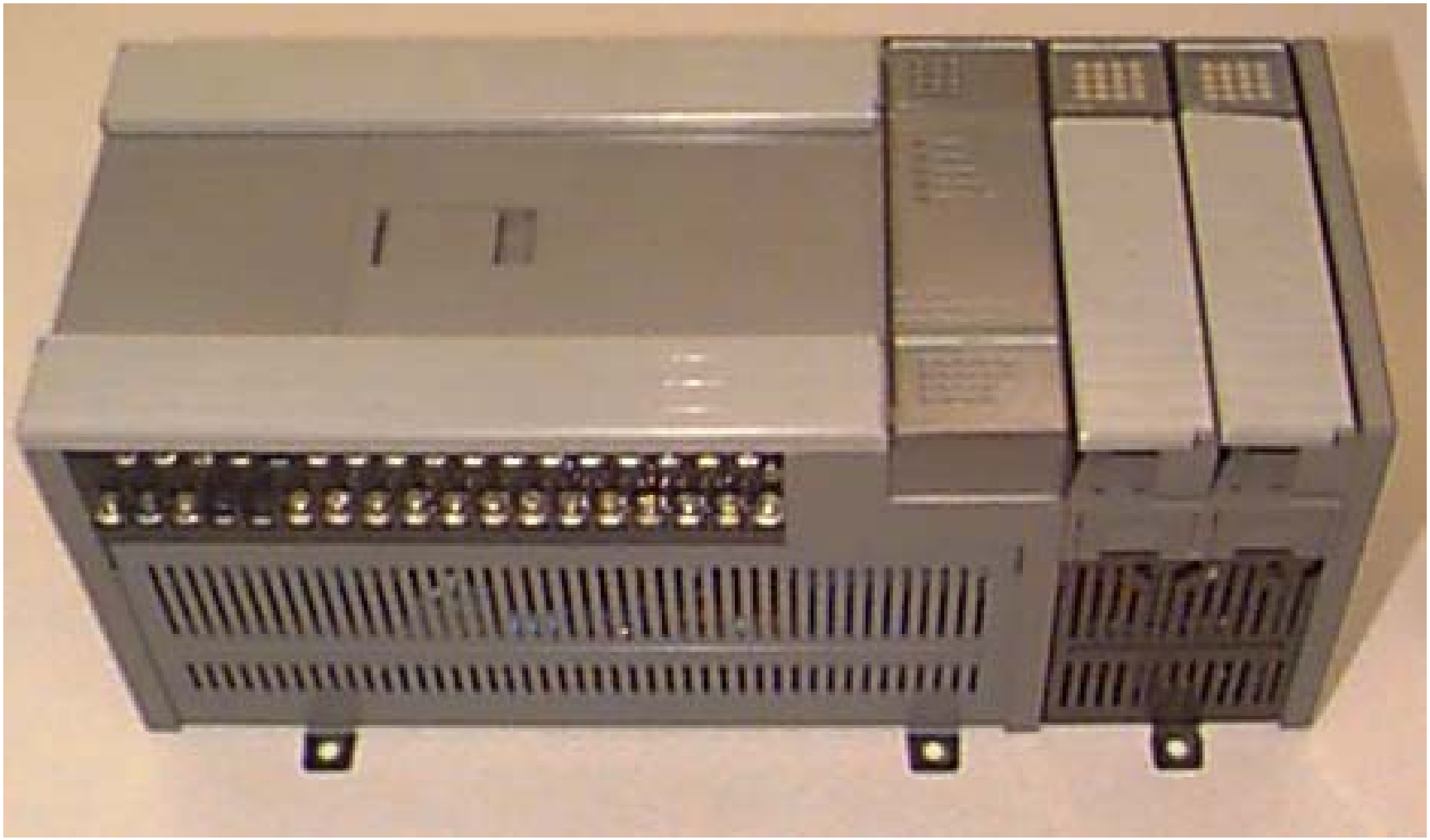
- I/O (Input/Output) - A number of input/output terminals must be provided so that the PLC can monitor the process and initiate actions.
- Indicator lights - These indicate the status of the PLC including power on, program running, and a fault. These are essential when diagnosing problems.

- The configuration of the PLC refers to the packaging of the components. Typical configurations are listed below from largest to smallest.

1. Rack - A rack is often large (up to 18” by 30” by 10”) and can hold multiple cards. When necessary, multiple racks can be connected together. These tend to be the highest cost, but also the most flexible and easy to maintain.



2. Mini - These are smaller than full sized PLC racks, but can have the same IO capacity.



3. Micro - These units can be as small as a deck of cards. They tend to have fixed quantities of I/O and limited abilities, but costs will be the lowest.

4. Software - A software based PLC requires a computer with an interface card, but allows the PLC to be connected to sensors and other PLCs across a network.

INPUTS AND OUTPUTS

- Inputs to, and outputs from, a PLC are necessary to monitor and control a process.
- Both inputs and outputs can be categorized into two basic types: logical or continuous. Consider an example of a light bulb. If it can only be turned on or off, it is logical control.

- If the light can be dimmed to different levels, it is continuous. Continuous values seem more intuitive, but logical values are preferred because they allow more certainty, and simplify control.
- As a result most controls applications (and PLCs) use logical inputs and outputs for most applications.

- **Outputs** the actuators allow a PLC to cause an action to happen in a process. A short list of popular **actuators** is given below.

1. Solenoid Valves - logical outputs that can switch a hydraulic or pneumatic flow.

2. Lights - logical outputs that can often be powered directly from PLC output boards.
3. Motor Starters - motors often draw a large amount of current when started, so they require motor starters, which are basically large relays.

4. Servo Motors - a continuous output from the PLC can command a variable speed or position.

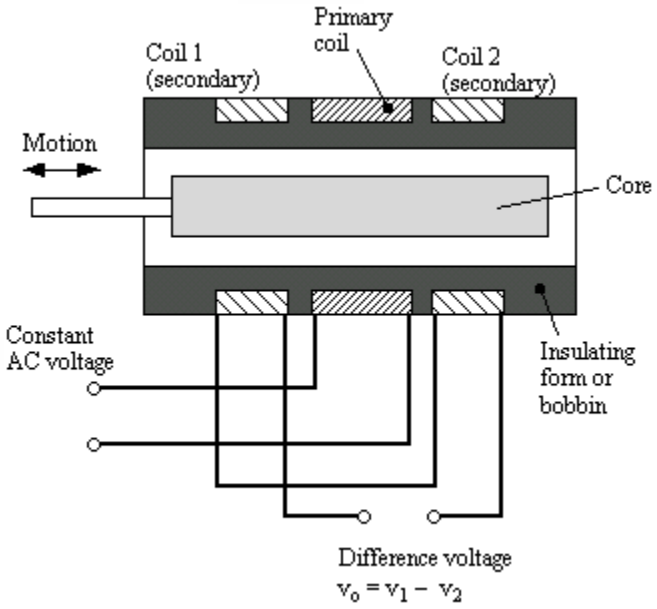
- Outputs from PLCs are often relays, but they can also be solid state electronics such as **transistors** for **DC outputs** or **Triacs** for **AC outputs**. Continuous outputs require special output cards with digital to analog converters.
- Inputs come from sensors that translate physical phenomena into electrical signals. Typical examples of sensors are listed below.

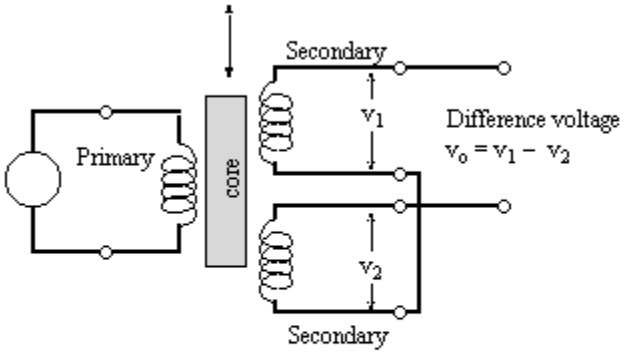
1. Proximity Switches - use inductance, capacitance or light to detect an object logically.

2. Switches - mechanical mechanisms will open or close electrical contacts for a logical signal.

3. Potentiometer - measures angular positions continuously, using resistance.

4. LVDT (linear variable differential transformer) - measures linear displacement continuously using magnetic coupling.





- Inputs for a PLC come in a few basic varieties, the simplest are AC and DC inputs.
- Sourcing and sinking inputs are also popular. This output method dictates that a device does not supply any power. Instead, the device only switches current on or off, like a simple switch.
- Sinking - When active, the output allows current to flow to a common ground. This is best selected when different voltages are supplied.
- Sourcing - When active, current flows from a supply, through the output device and to ground. This method is best used when all devices use a single supply voltage.

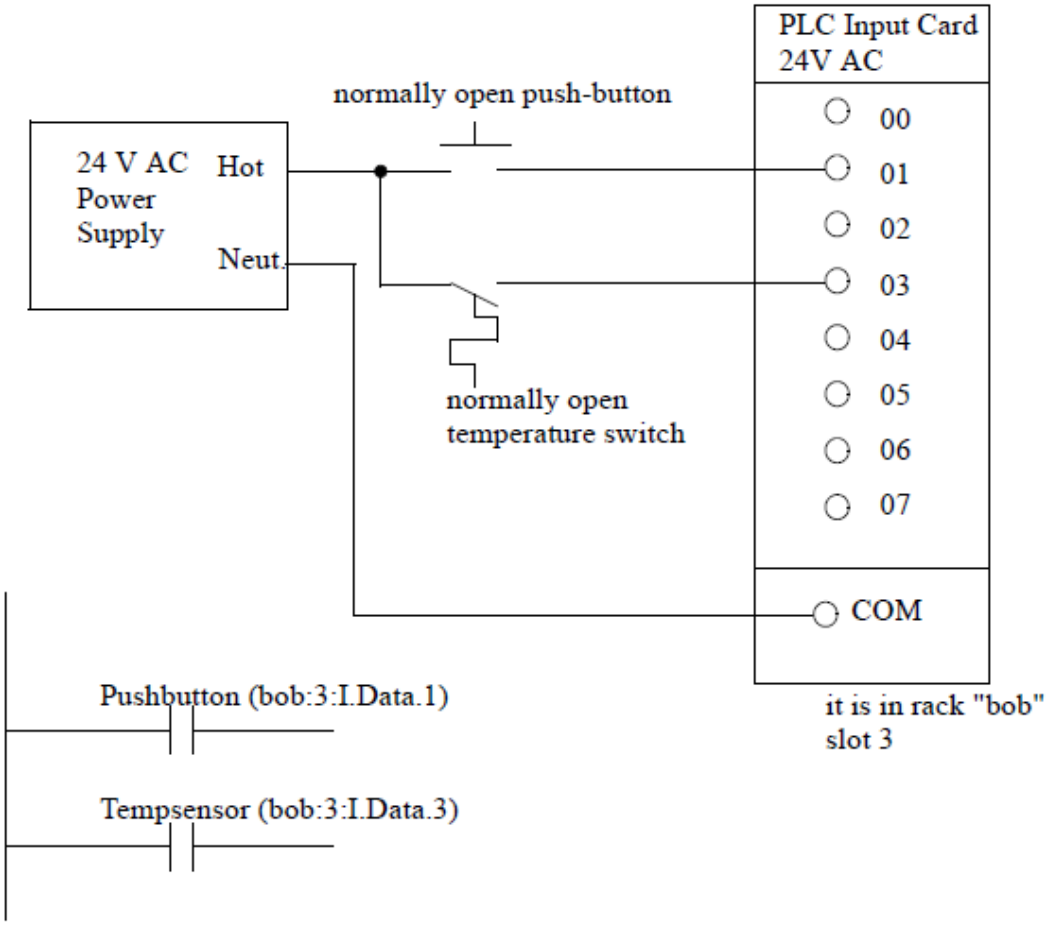
- This is also referred to as NPN (sinking) and PNP (sourcing). PNP is more popular.

Inputs

- In smaller PLCs the inputs are normally built in and are specified when purchasing the PLC.
- For larger PLCs the inputs are purchased as modules, or cards, with 8 or 16 inputs of the same type on each card. The list below shows typical ranges for input voltages in order of popularity.

1. 12-24 Vdc
2. 100-120 Vac
3. 10-60 Vdc
4. 12-24 Vac/dc
5. 5 Vdc (TTL)
6. 200-240 Vac
7. 48 Vdc
8. 24 Vac

- PLC input cards rarely supply power, this means that an external power supply is needed to supply power for the inputs and sensors, as shown how to connect an AC input card.
- inputs are normally high impedance. This means that they will use very little current.
- There are two inputs, one is a normally open push button, and the second is a temperature switch, or thermal relay.



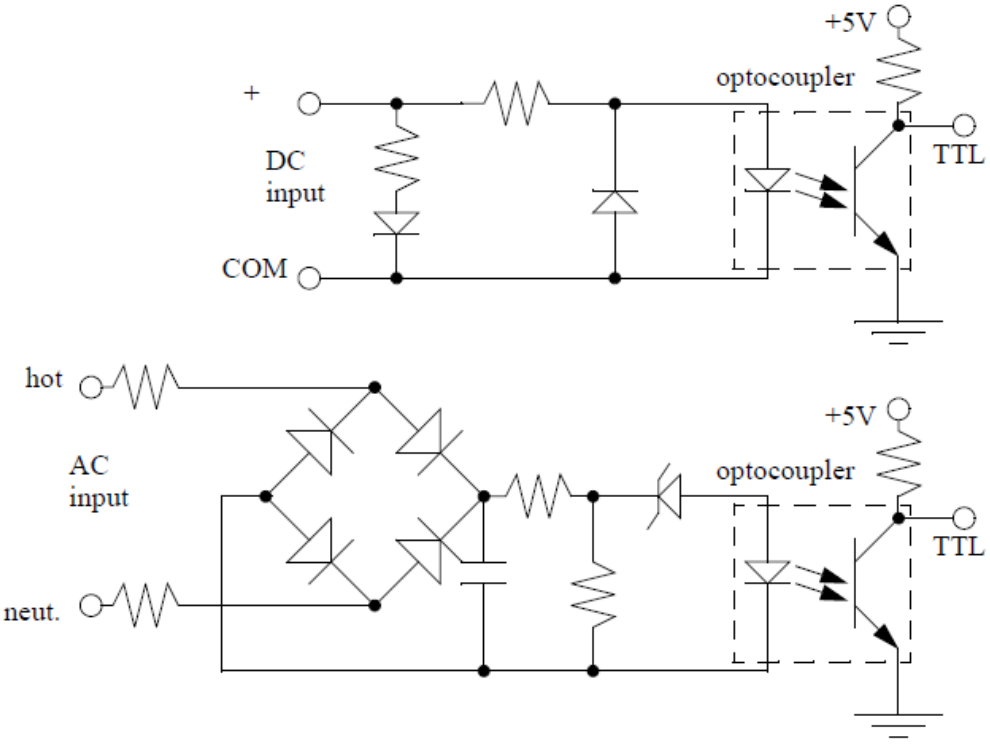
- The design process will be much easier if the inputs and outputs are planned first.
- Tags are entered before the ladder logic.
- The program is entered using the much simpler tag names.

Trade-offs when deciding which type of input cards to use.

1. DC voltages are usually lower, and therefore safer (12-24V).
2. DC inputs are very fast, AC inputs require a longer on-time. For example, a 50Hz wave may require up to 1/50 sec for reasonable recognition.
3. DC voltages can be connected to larger variety of electrical systems.
4. AC signals are more immune to noise than DC, so they are suited to long distances, and noisy (magnetic) environments.
5. AC power is easier and less expensive to supply to equipment.
6. AC signals are very common in many existing automation devices.

- PLC inputs must convert a variety of logic levels to the 5Vdc logic levels used on the data bus. This can be done with circuits shown below. The circuits condition the input to drive an optocoupler.

- This electrically isolates the external electrical circuitry from the internal circuitry. Other circuit components are used to guard against excess or reversed voltage polarity.

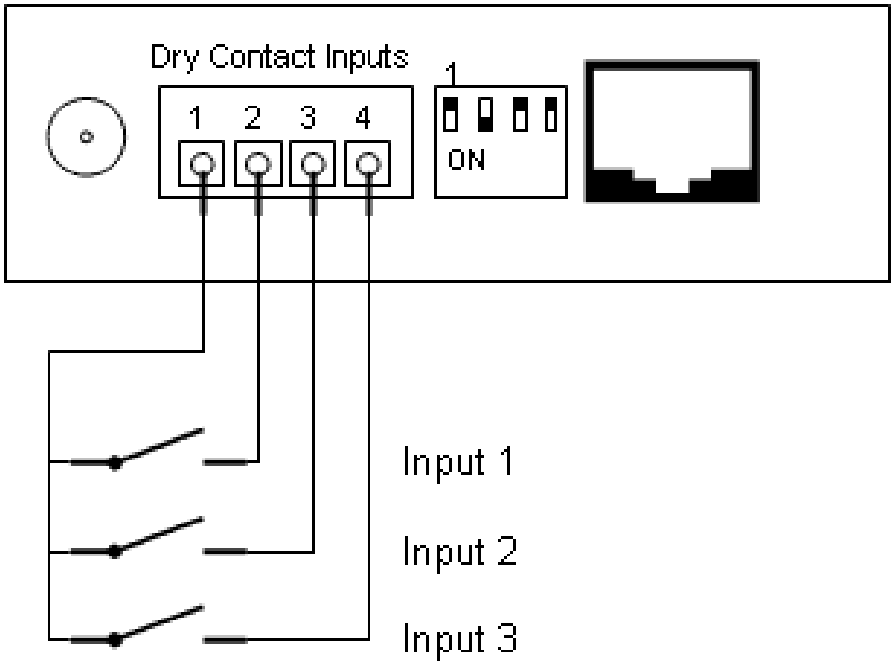


- As with input modules, output modules rarely supply any power, but instead act as switches.
- External power supplies are connected to the output card and the card will switch the power on or off for each output.
- Typical output voltages are listed below, and ordered by popularity.

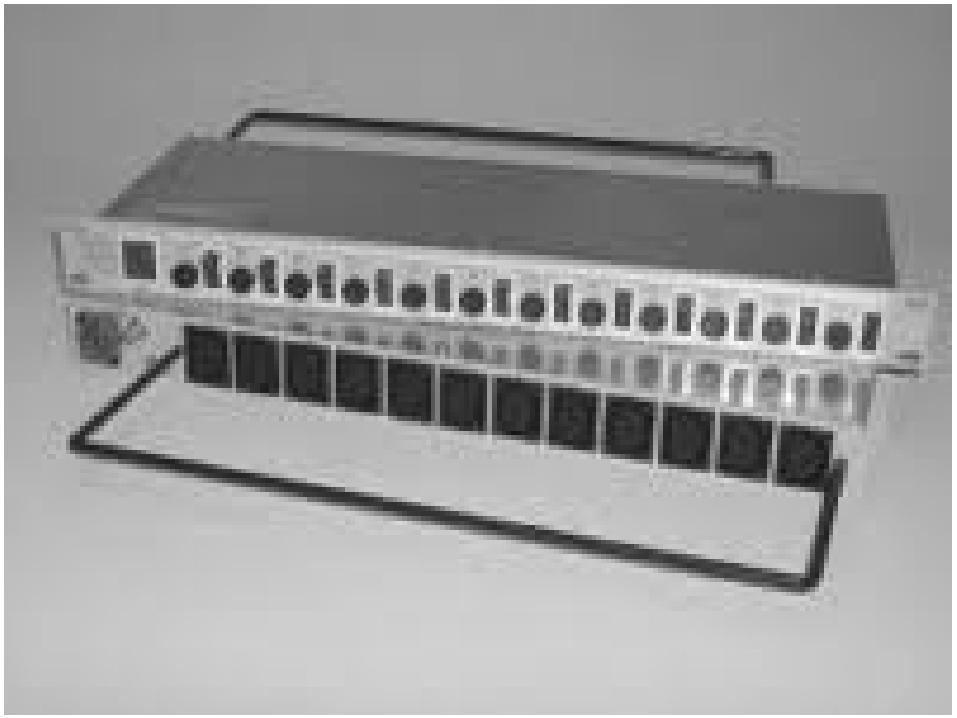
1. 120 Vac
2. 24 Vdc
3. 12-48 Vac
4. 12-48 Vdc
5. 5Vdc (TTL)
6. 230 Vac

- The output cards typically have 8 to 16 outputs of the same type and can be purchased with different current ratings.
- A common choice when purchasing output cards is relays, transistors or triacs.
- Relays are the most flexible output devices. They are capable of switching both AC and DC outputs. But, they are slower (about 10ms switching is typical), they are bulkier, they cost more, and they will wear out after **millions of cycles**.
- **Relay outputs** are often called **dry contacts**. Transistors are limited to DC outputs, and Triacs are limited to AC outputs. **Transistor and triac outputs are called switched outputs**.

- Dry contacts - a separate relay is dedicated to each output. This allows mixed voltages (AC or DC and voltage levels up to the maximum), as well as isolated outputs to protect other outputs and the PLC. Response times are often greater than 10ms. This method is the least sensitive to voltage variations and spikes.

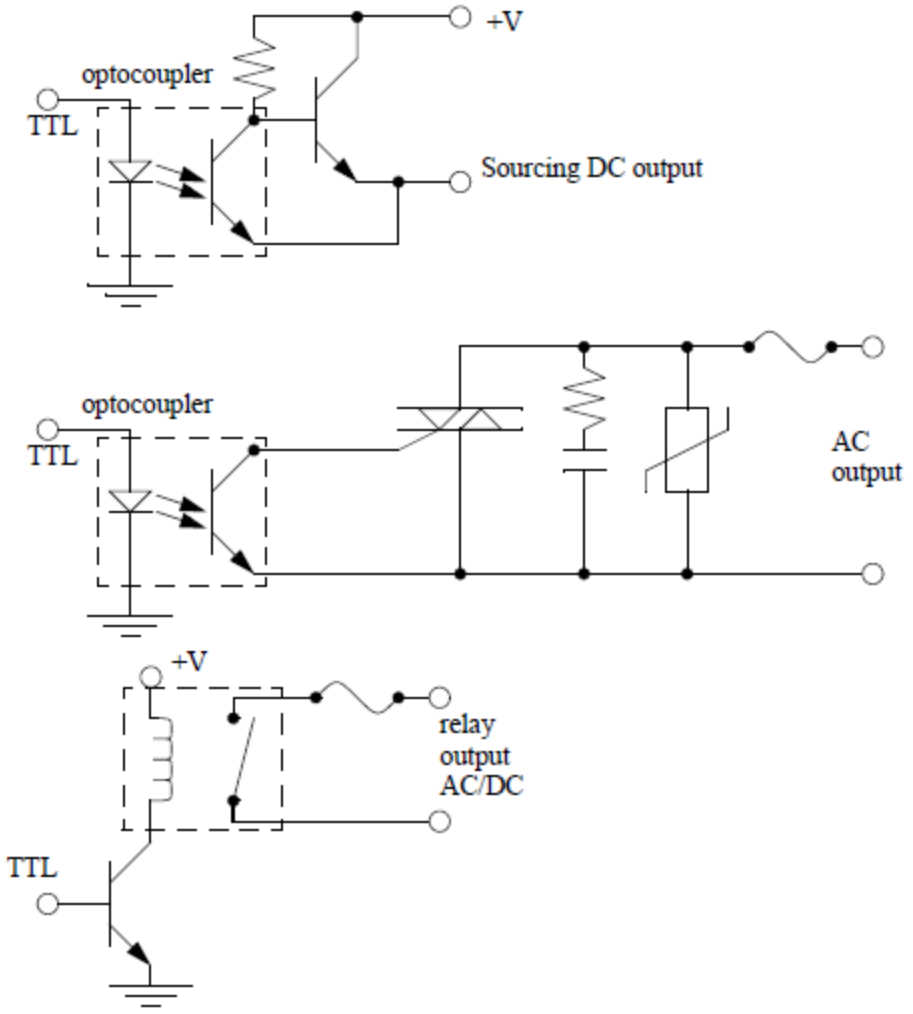


- Switched outputs - a voltage is supplied to the PLC card, and the card switches it to different outputs using solid state circuitry (transistors, triacs, etc.) Triacs are well suited to AC devices requiring less than 1A. Transistor outputs use NPN or PNP transistors up to 1A typically. Their response time is well under 1ms.



- PLC outputs must convert the 5Vdc logic levels on the PLC data bus to external voltage levels. This can be done with circuits similar to those shown below.

- The circuits use an optocoupler to switch external circuitry. This electrically isolates the external electrical circuitry from the internal circuitry. Other circuit components are used to guard against excess or reversed voltage polarity.



- The output card shown below is an example of a 24Vdc output card that has a shared common. This type of output card would typically use transistors for the outputs.

- An Example of a 24Vdc Output Card (Sinking)