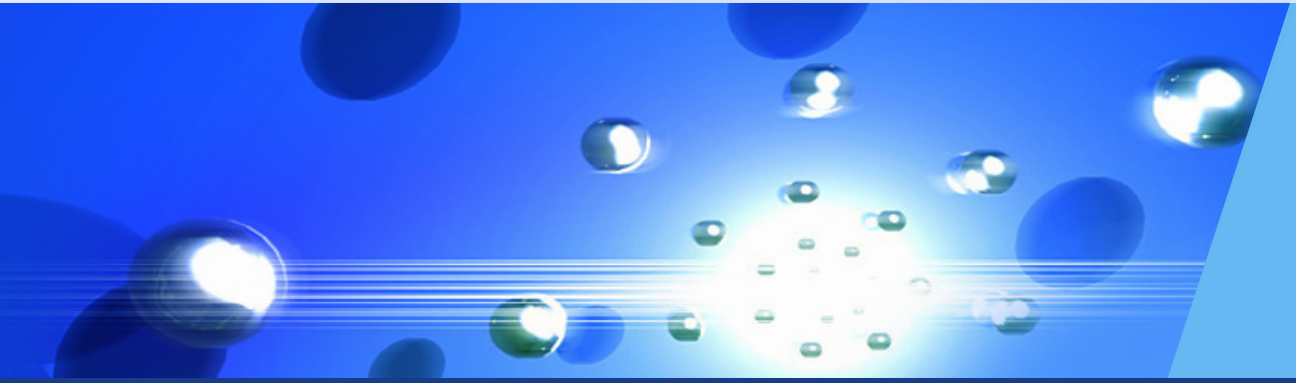
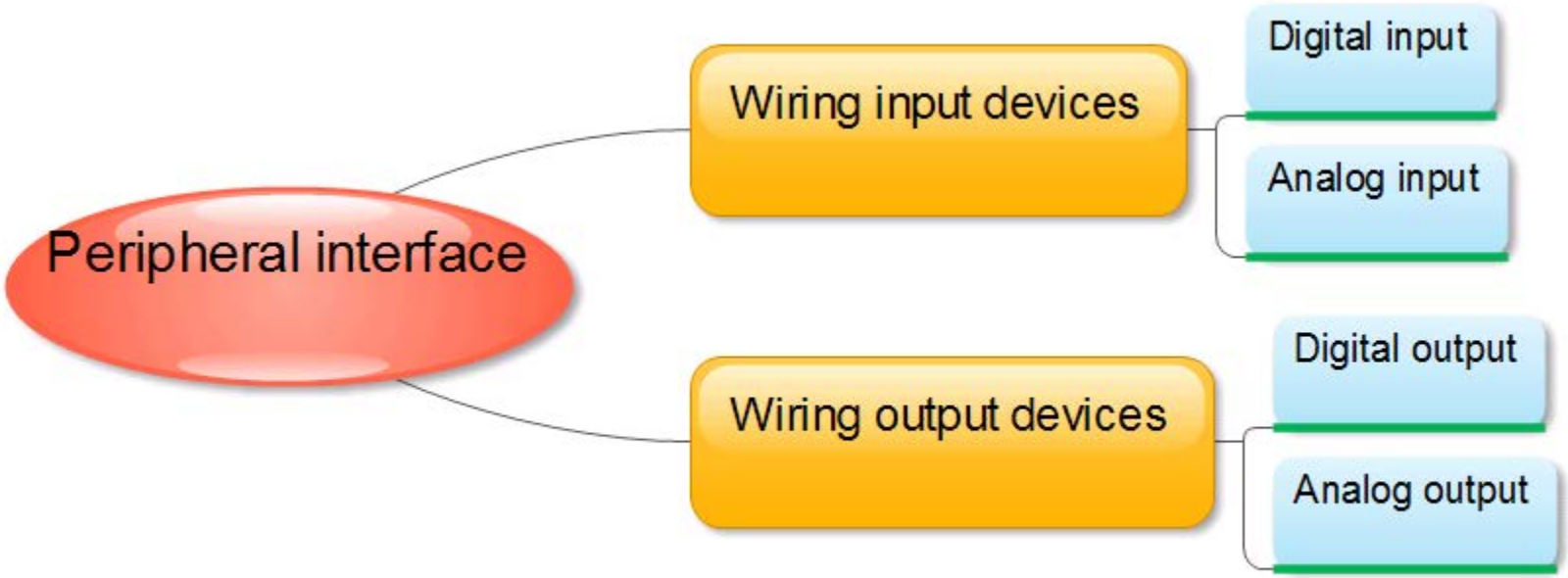


# Chapter 5: Digital/Analog I/O System

# Peripheral interface



# Digital (discrete) Inputs

| Field Input Devices |
| --- |
| Circuit breakers |
| Level switches |
| Limit switches |
| Motor starter contacts |
| Photoelectric eyes |
| Proximity switches |
| Push buttons |
| Relay contacts |
| Selector switches |
| Thumbwheel switches (TWS) |

| Input Ratings |
| --- |
| 24 volts AC/DC |
| 48 volts AC/DC |
| 120 volts AC/DC |
| 230 volts AC/DC |
| TTL level |
| Nonvoltage |
| Isolated input |
| 5–50 volts DC (sink/source) |


**Thumbwheel switch (TWS)**

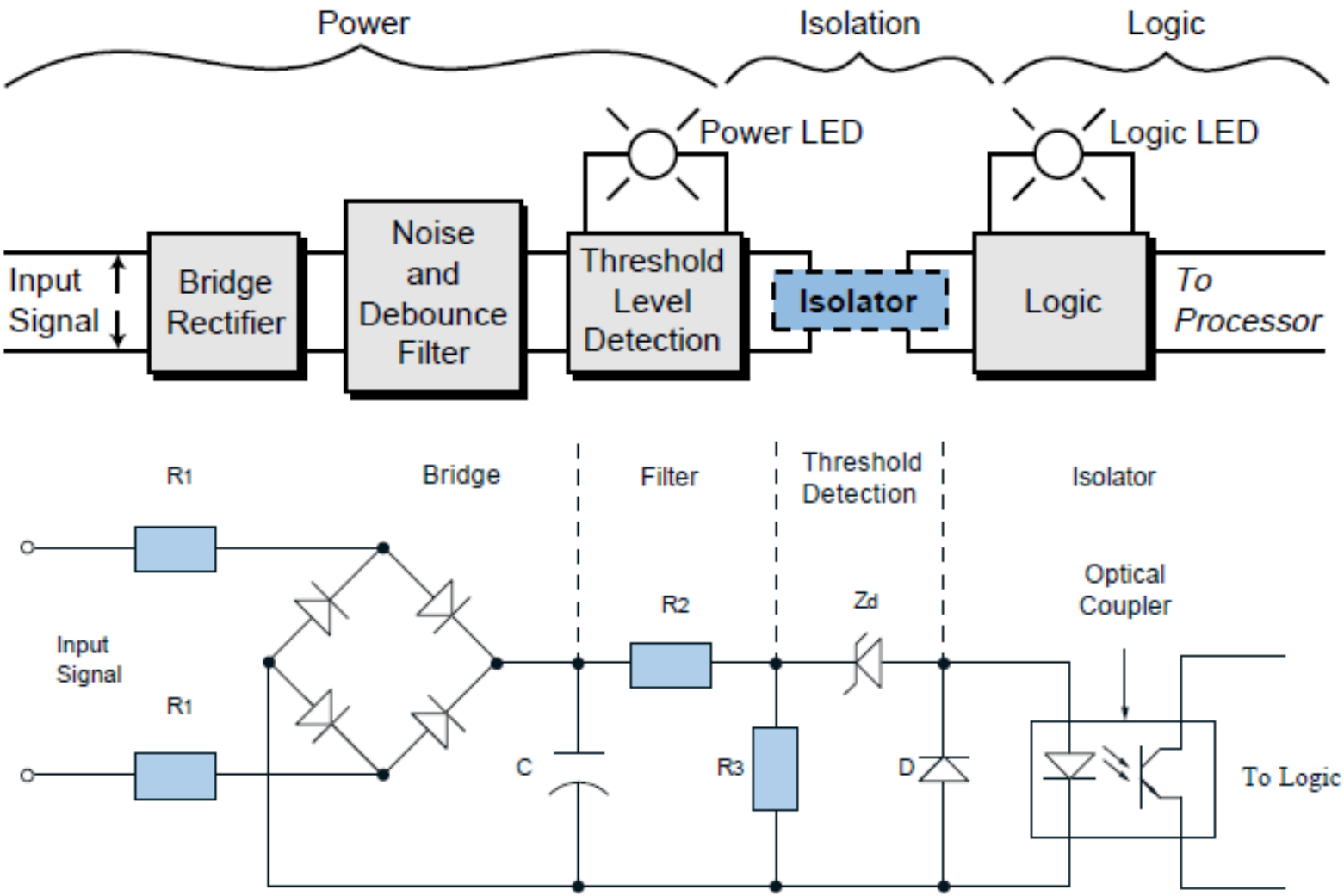
# Digital Inputs - Button

# Digital Inputs – Proximity Switch

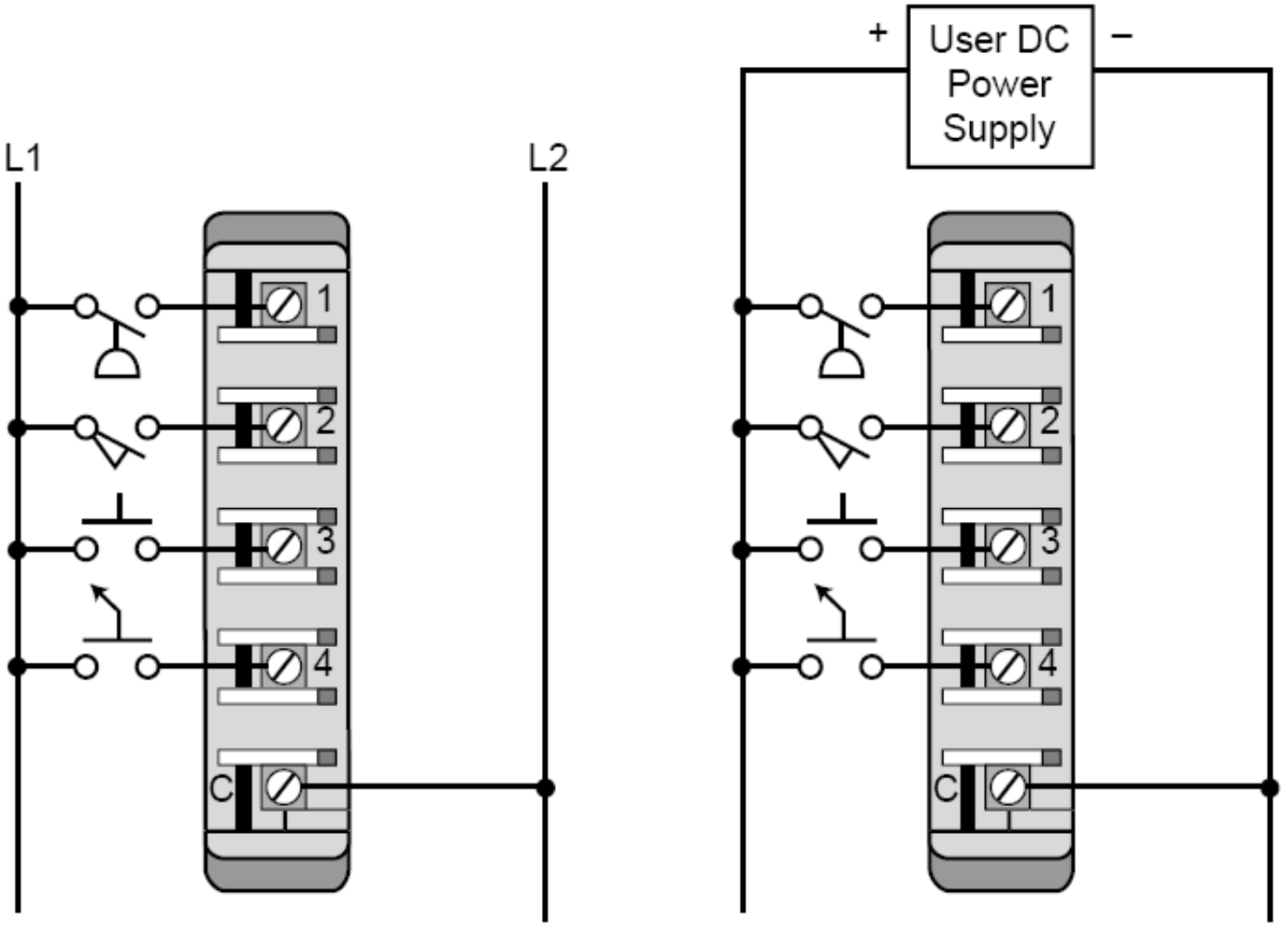
# Digital Inputs – Photoelectric Switch

# Digital Inputs – Limit Switch

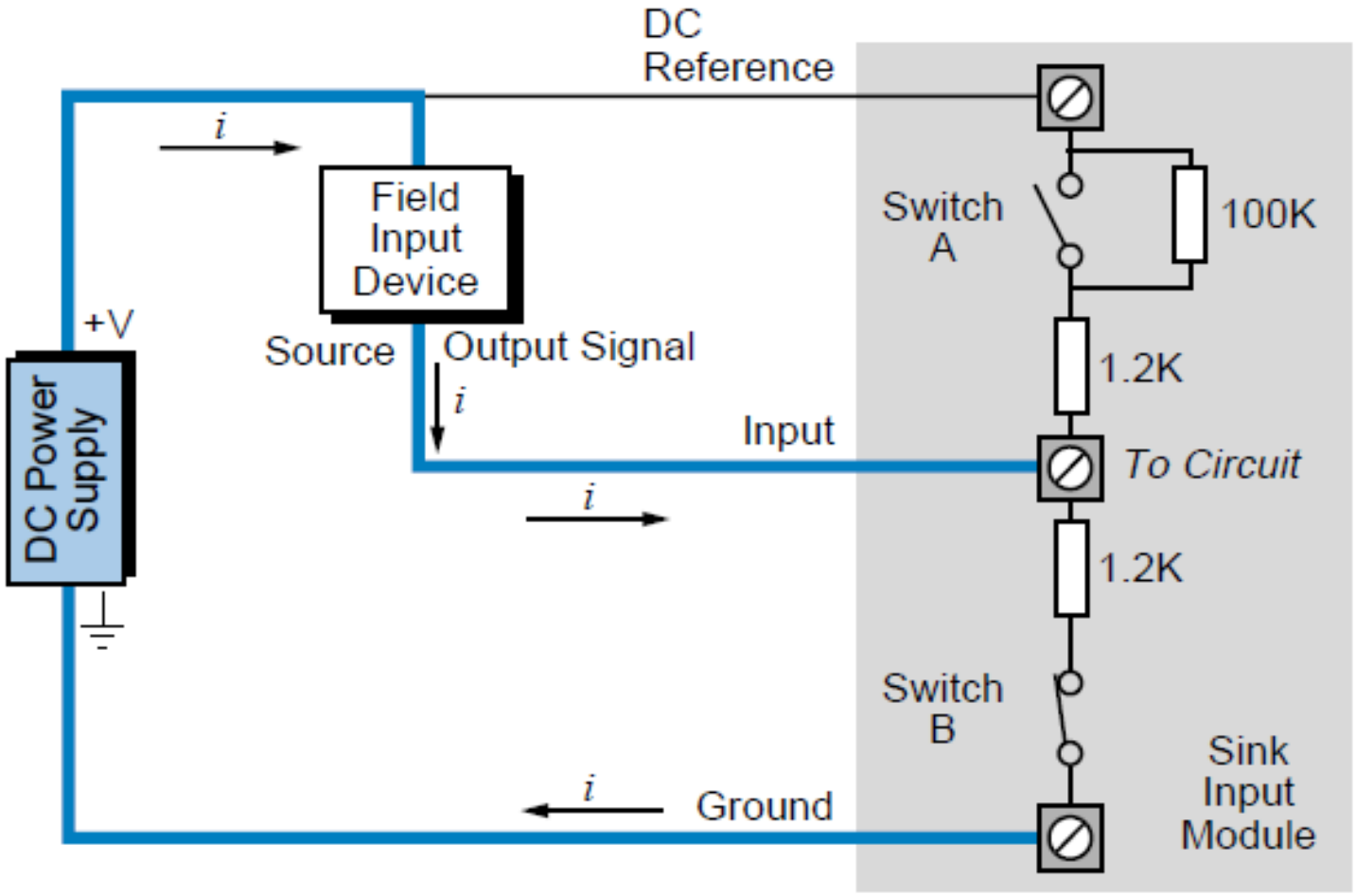
# Typical AC/DC Input Circuit



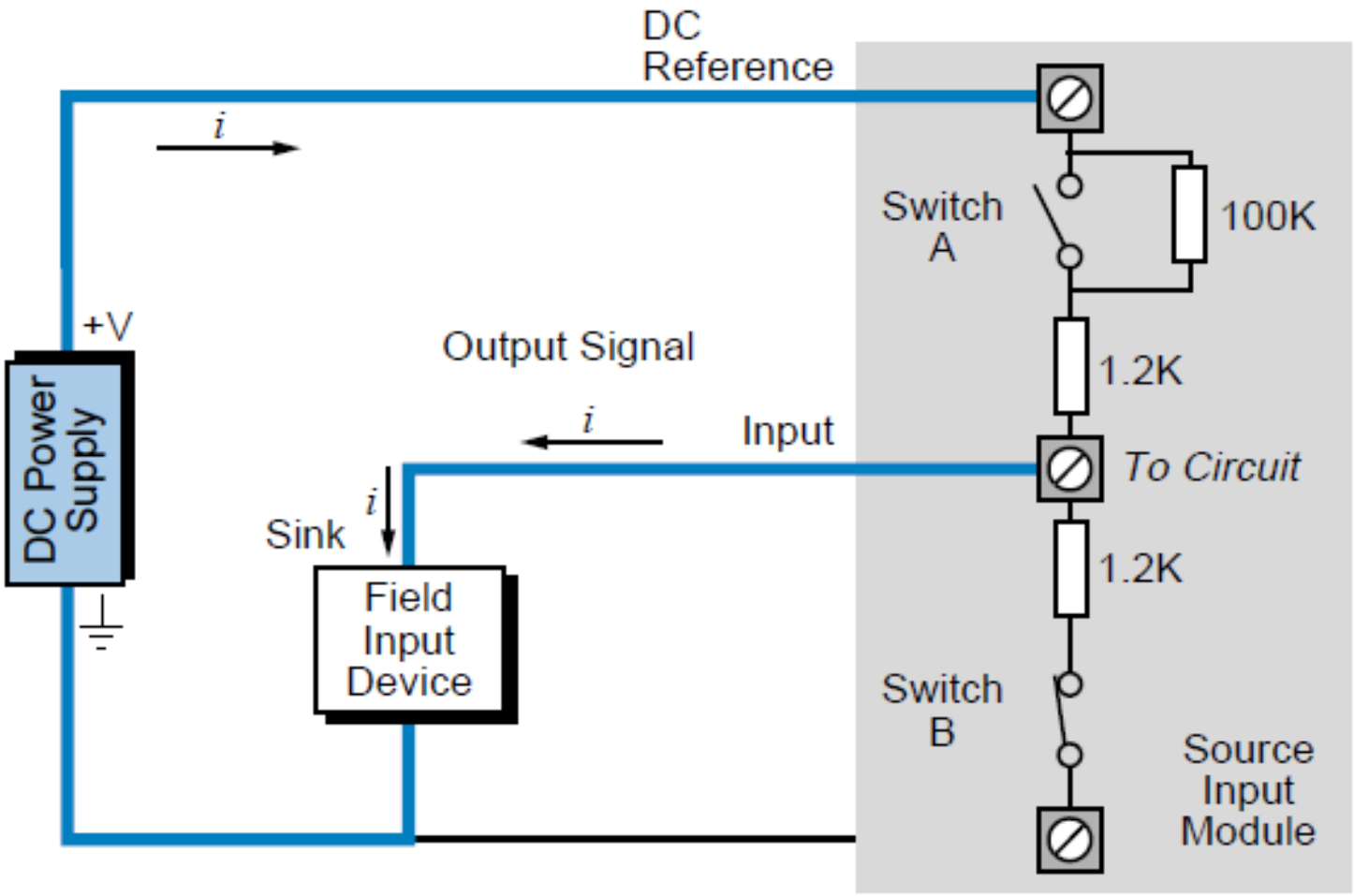
# Device Connections

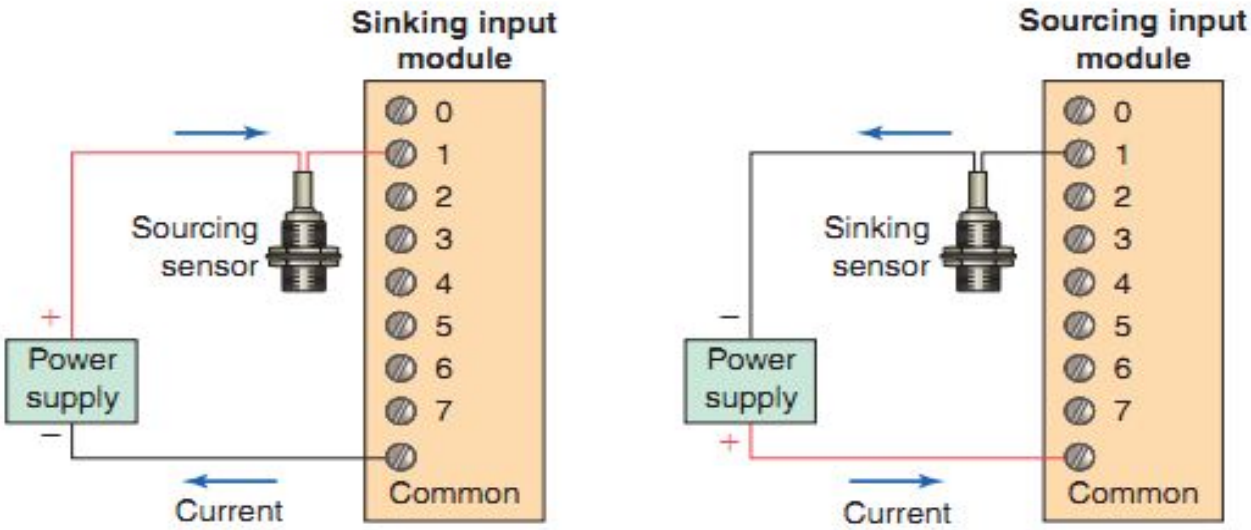


# DC Inputs – Source/Sink

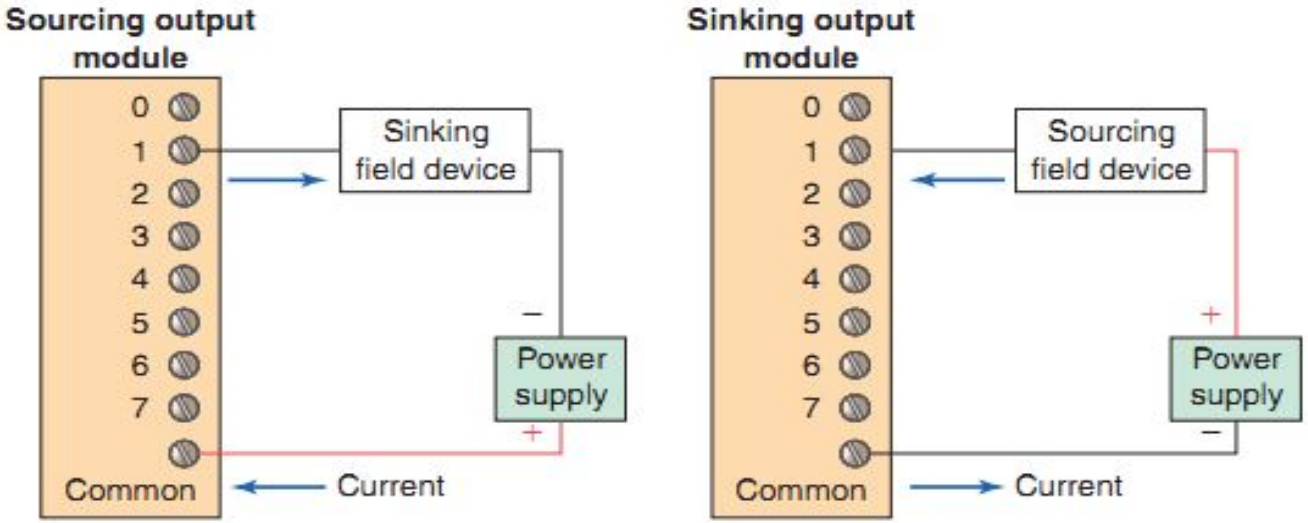


# DC Inputs – Source/Sink



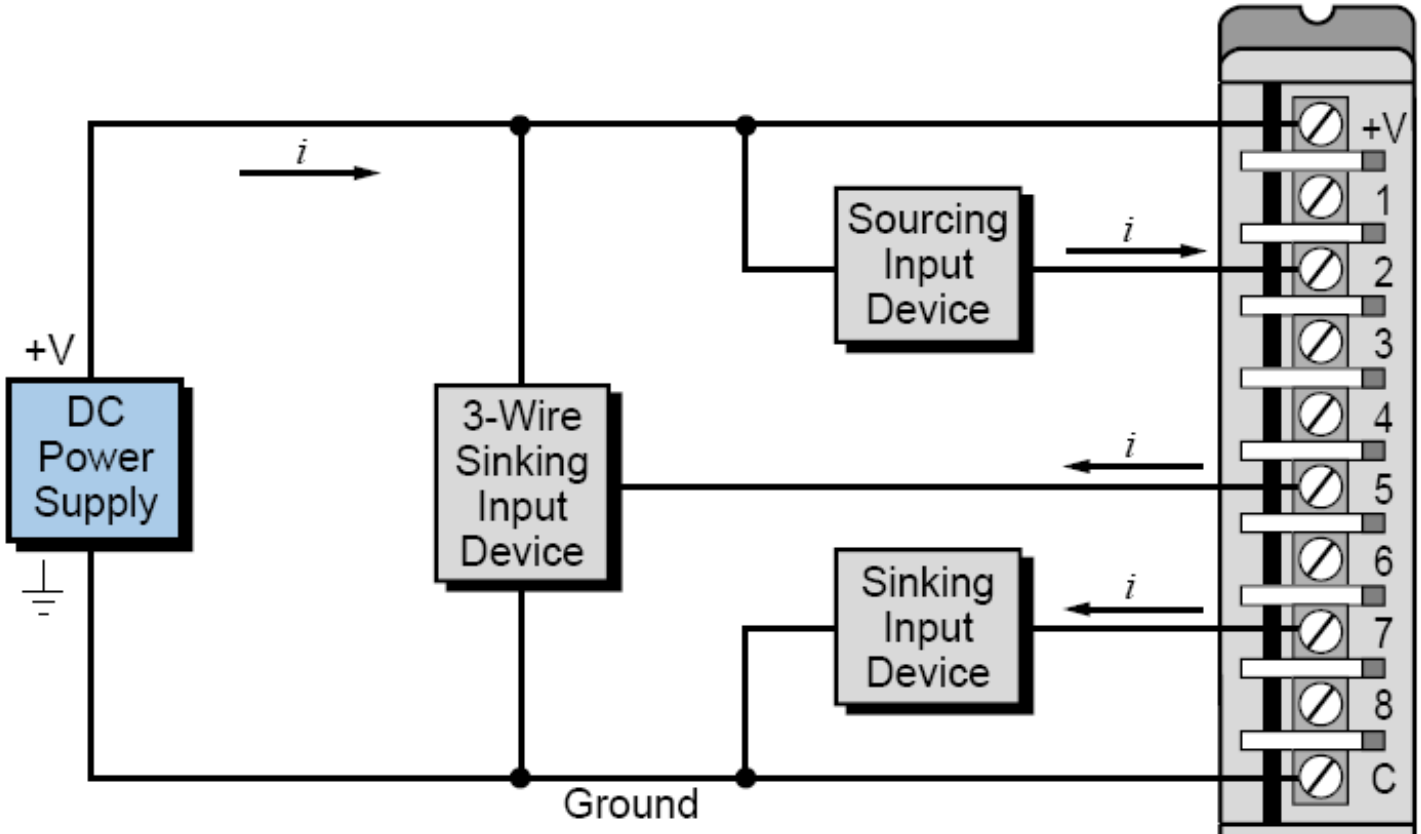



Sinking and sourcing inputs.



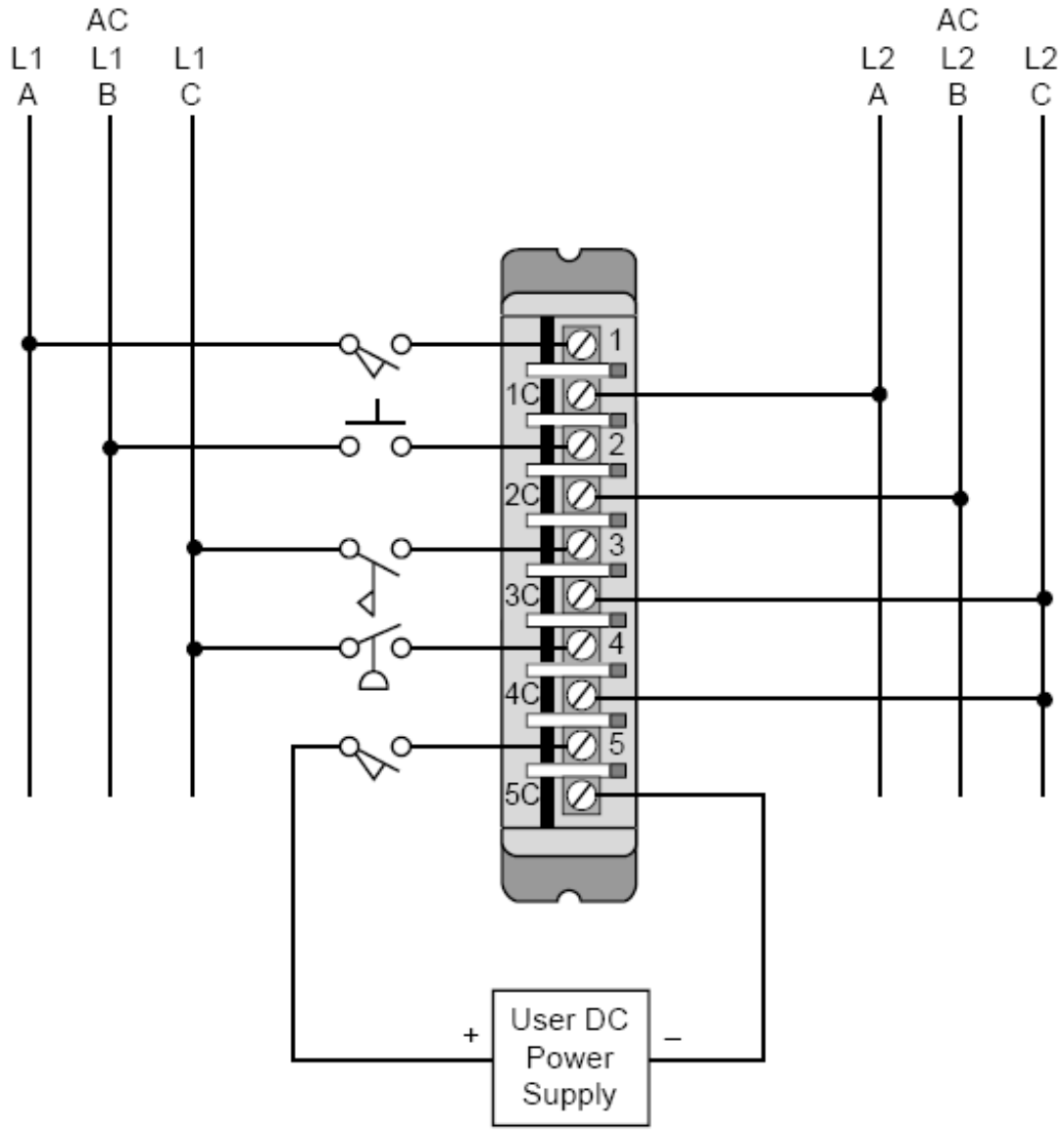

Sinking and sourcing outputs.

# DC Inputs – Source/Sink




**Sinking sensors allow current to flow into the sensor to the voltage common, while sourcing sensors allow current to flow out of the sensor from a positive source.**

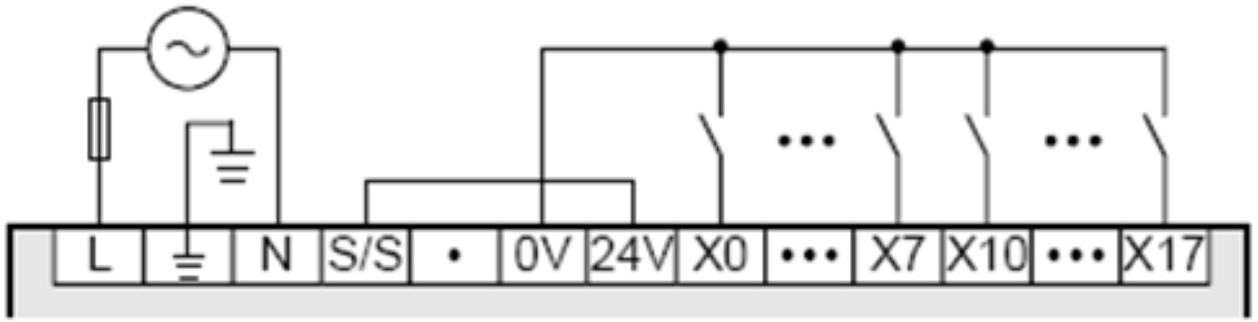
# Isolated AC/DC Inputs



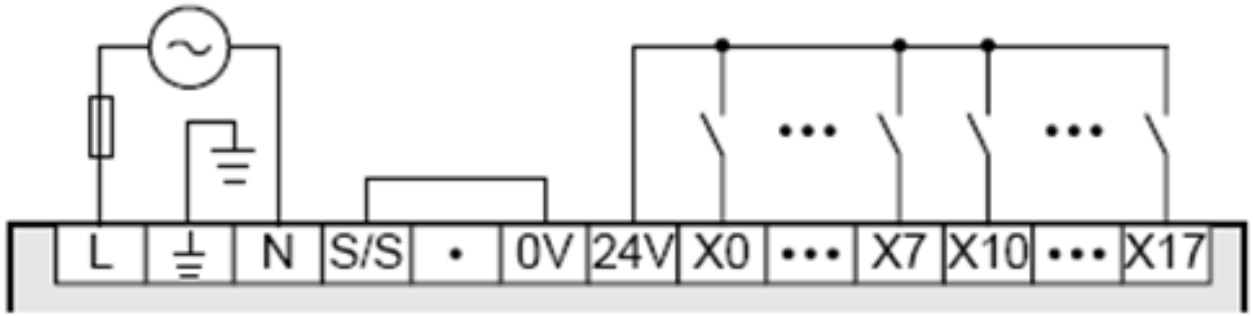
# PLC (Mitsubishi) Wiring

- Digital Inputs

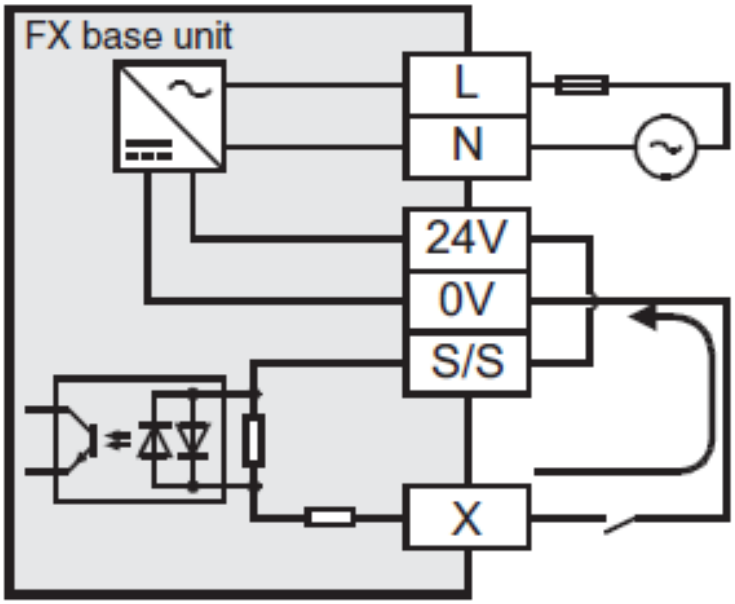
1) Sink



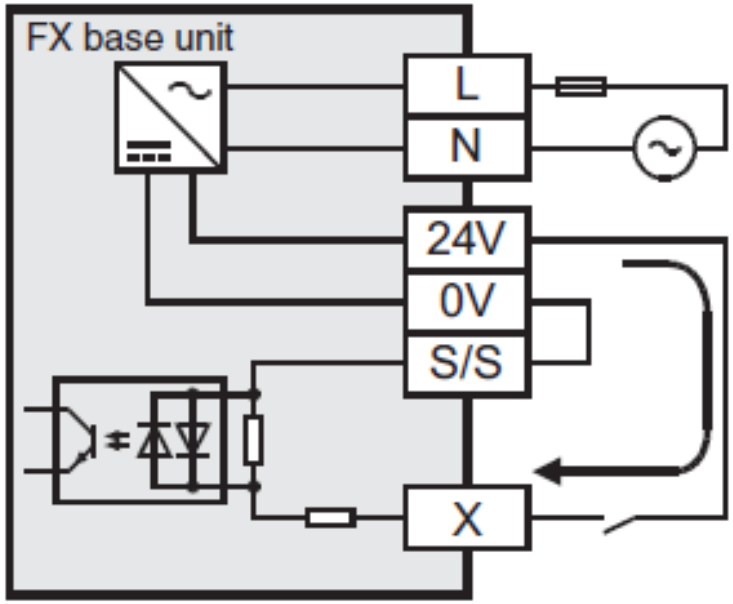

2) Source



# PLC (Mitsubishi) Wiring




**Sink** Input Type

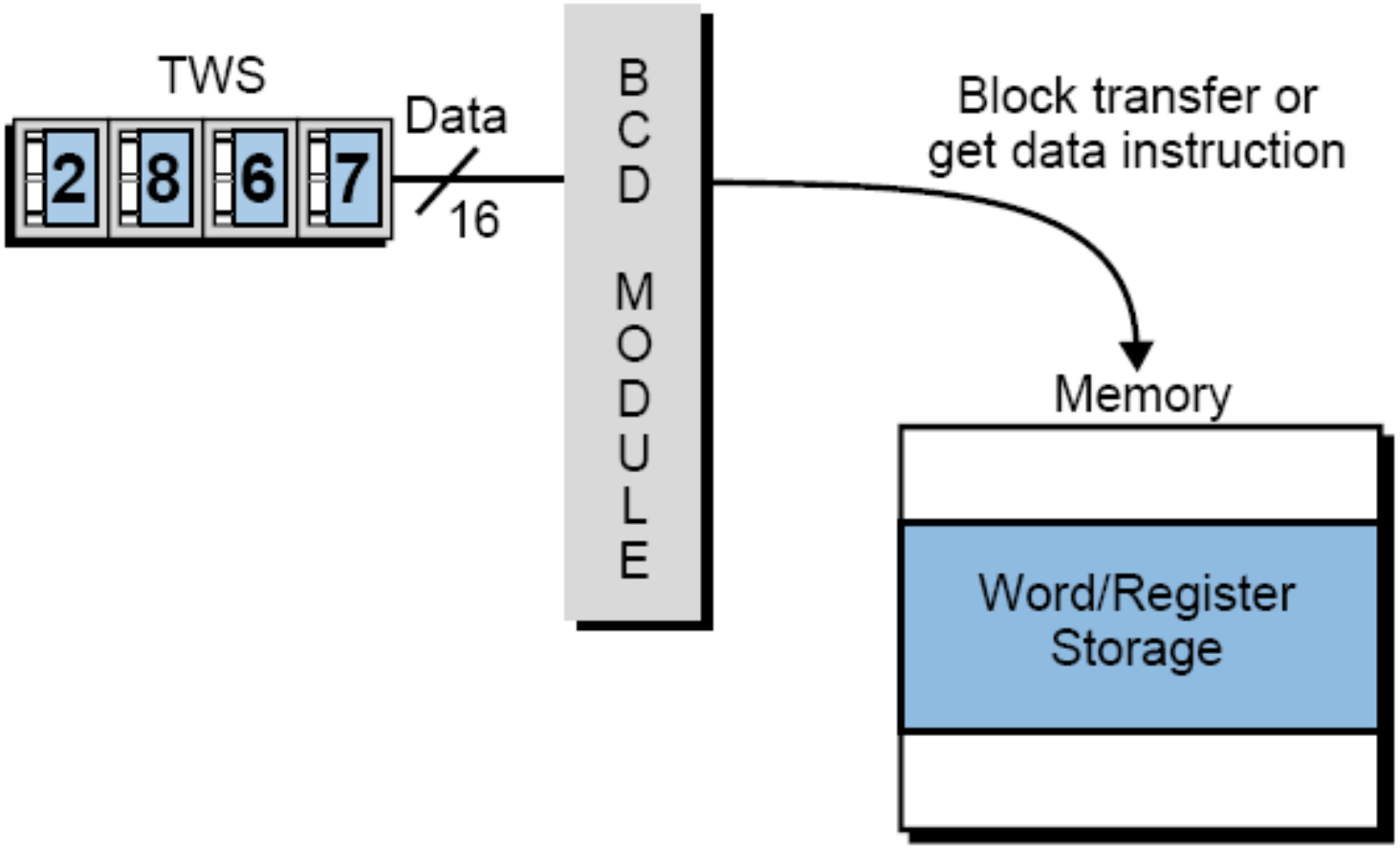



**Source** Input Type

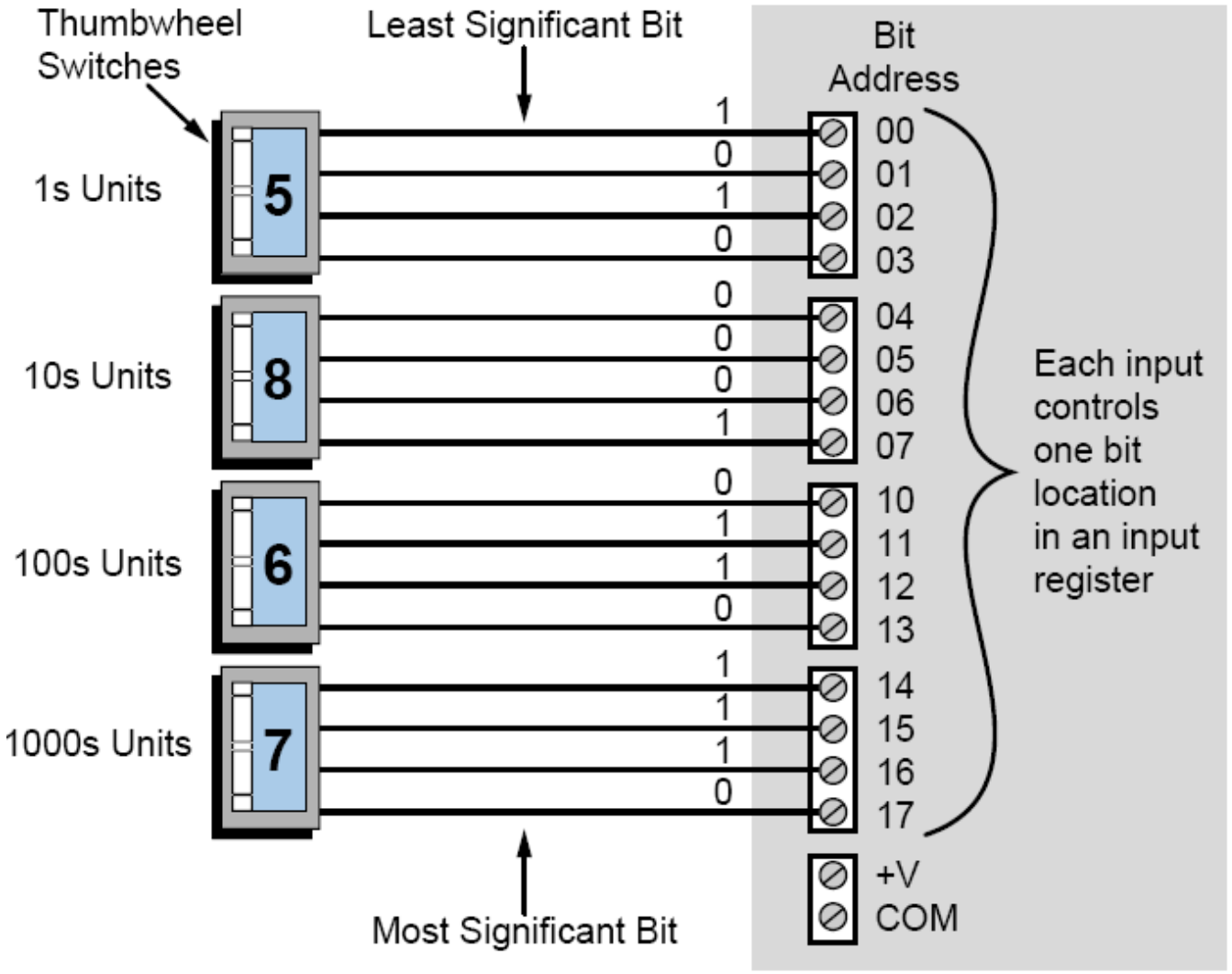
# Quiz

- **Given components and digital input with specific type as following, draw the connection:**
  - **2 switch to sink digital inputs**
  - **1 limit switch to source digital input**
  - **1 sink sensor to sink input**
  - **1 source sensor to source input**

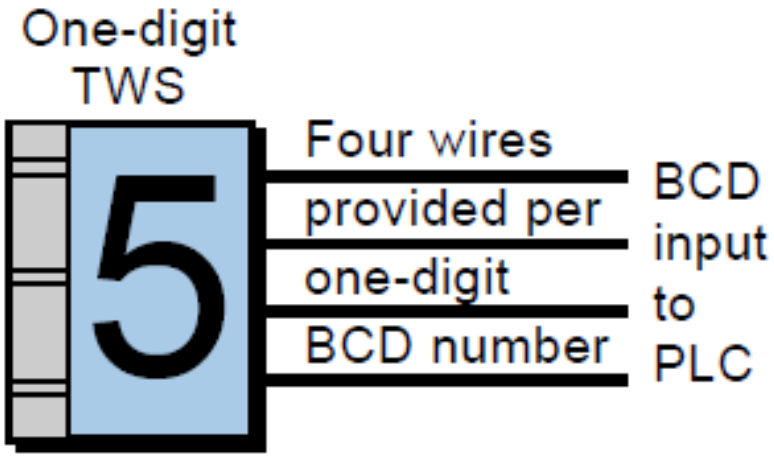
# Register/BCD Inputs

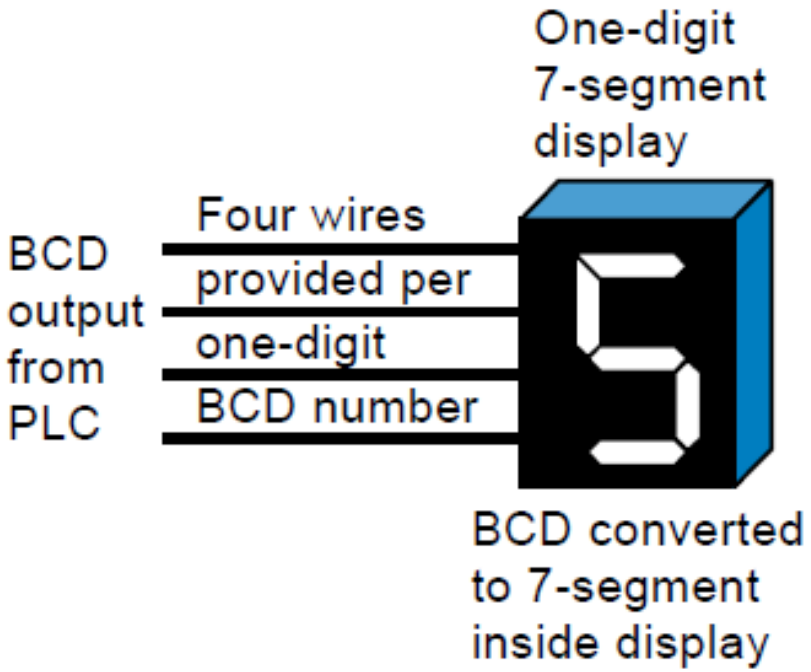


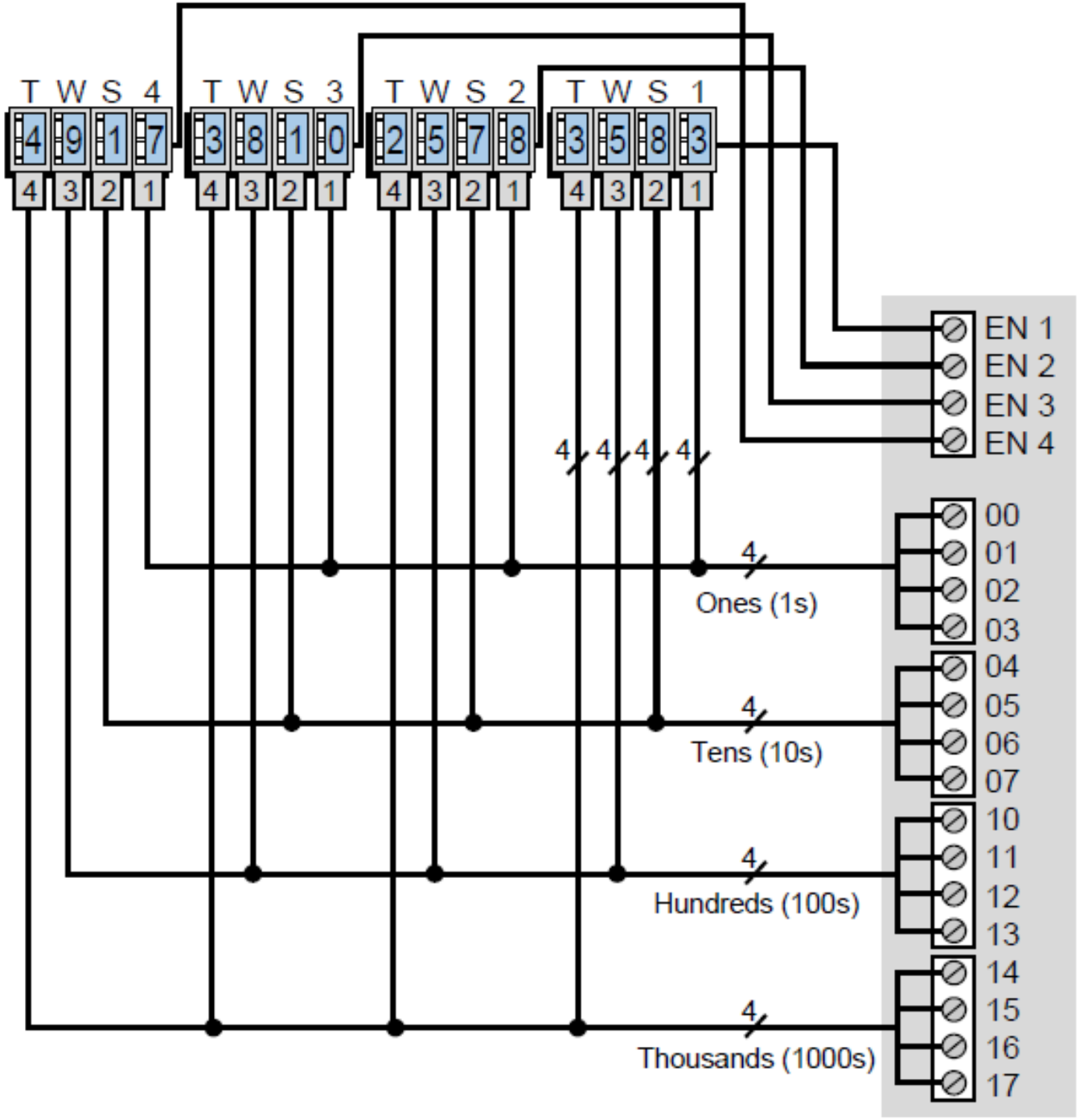
# Register/BCD Inputs



# Register/BCD Inputs




T W S 4
4 9 1 7
T W S 3
3 8 1 0
T W S 2
2 5 7 8
T W S 1
3 5 8 3
4 3 2 1
EN 1
EN 2
EN 3
EN 4
4
Ones (1s)
Tens (10s)
Hundreds (100s)
Thousands (1000s)
00
01
02
03
04
05
06
07
10
11
12
13
14
15
16
17

# Digital Outputs

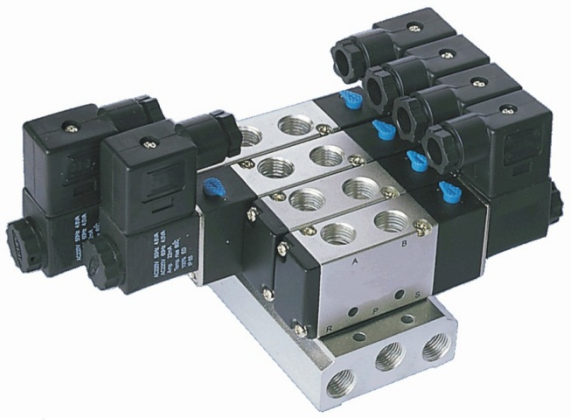
| Output Devices |
| --- |
| Alarms |
| Control relays |
| Fans |
| Horns |
| Lights |
| Motor starters |
| Solenoids |
| Valves |

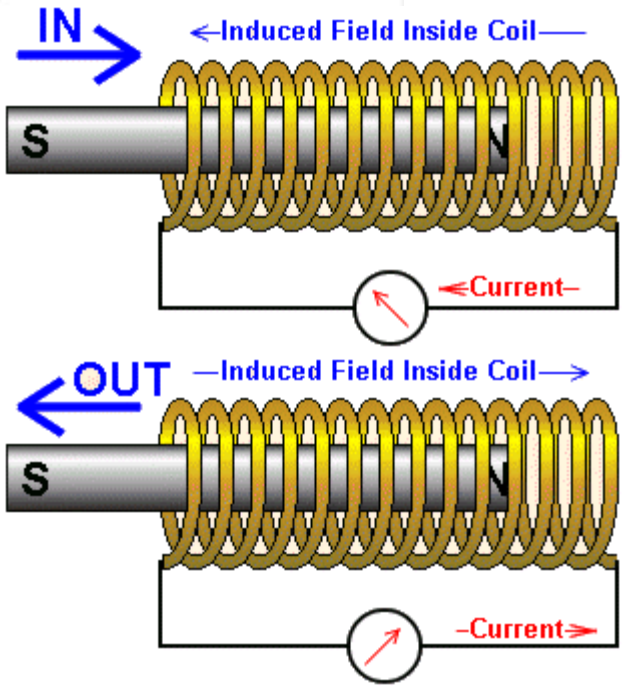
| Output Ratings |
| --- |
| 12–48 volts AC/DC |
| 120 volts AC/DC |
| 230 volts AC/DC |
| Contact (relay) |
| Isolated output |
| TTL level |
| 5–50 volts DC (sink/source) |

# Digital Devices

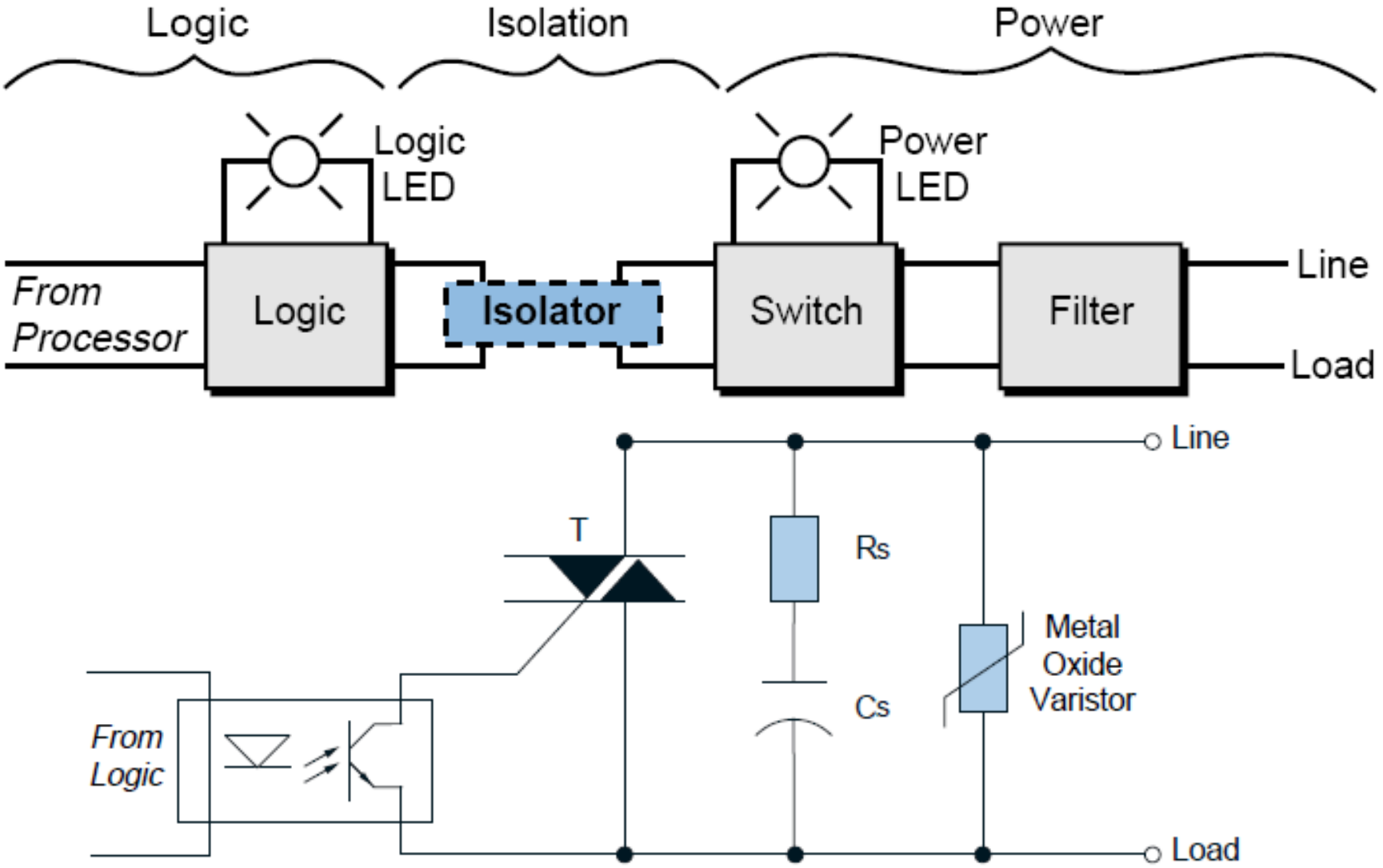


# Digital Devices

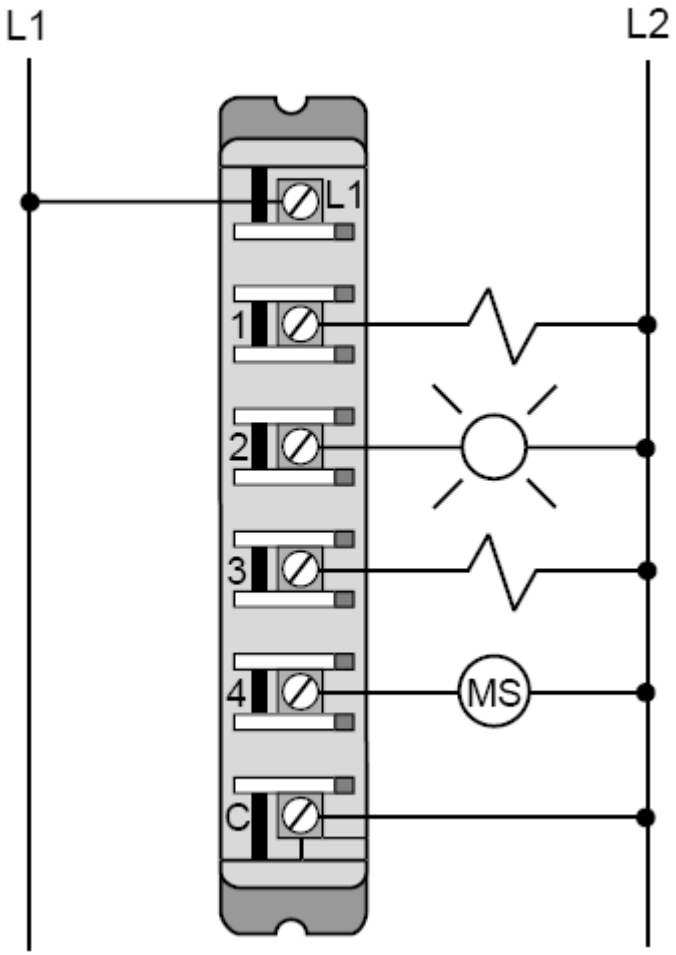



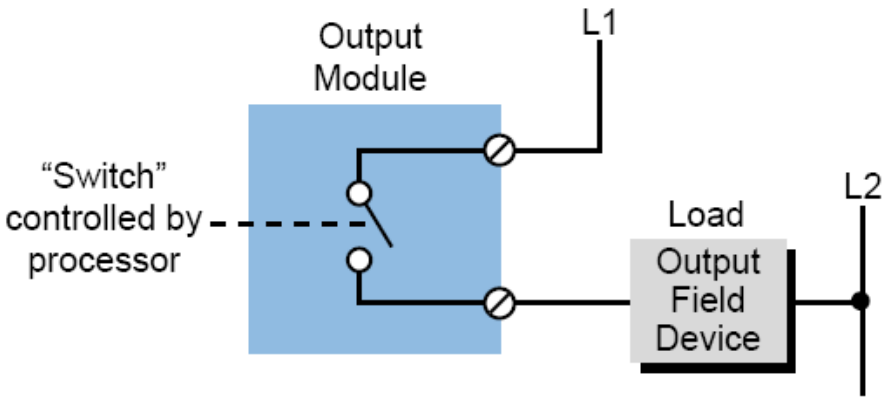


# Typical AC/DC Output Circuit

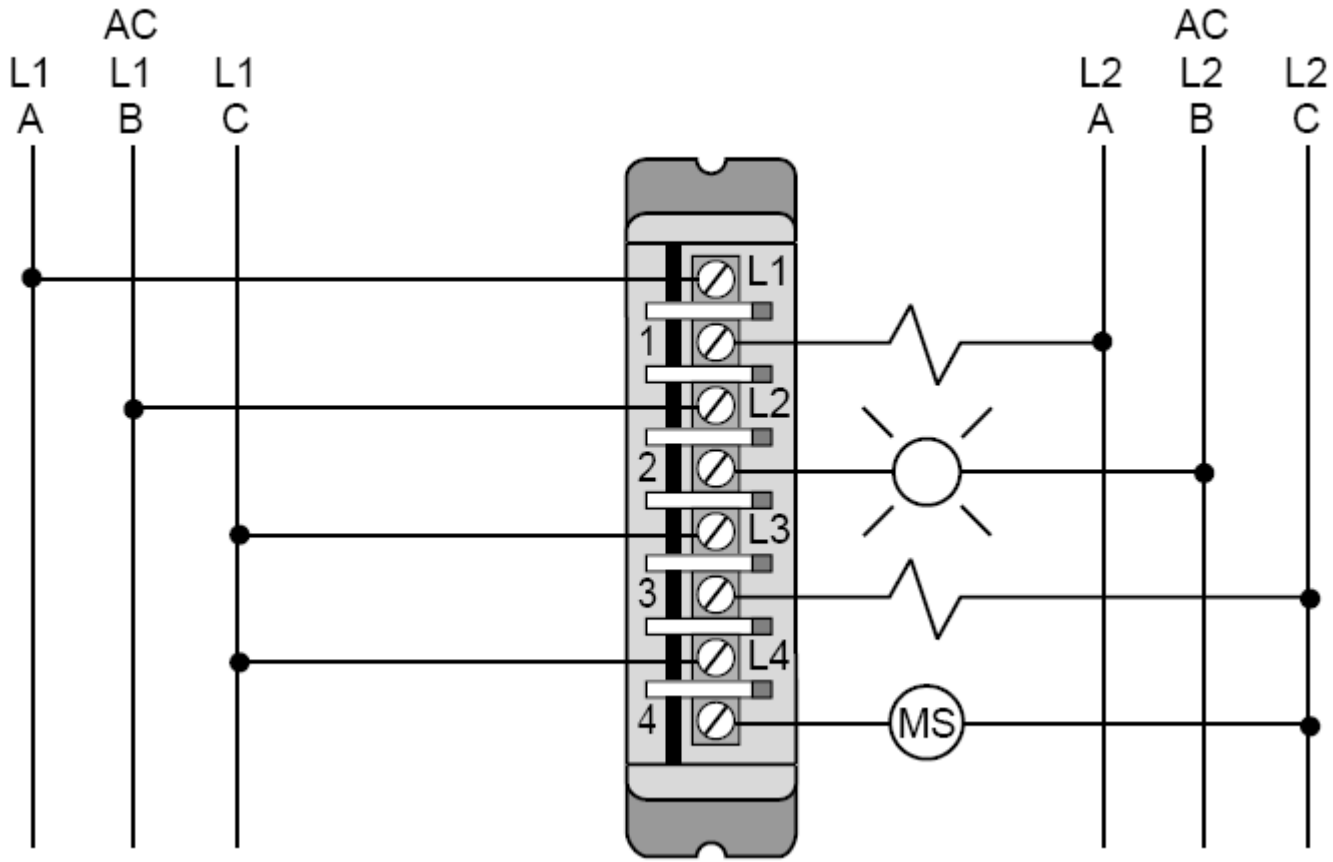


# AC Outputs

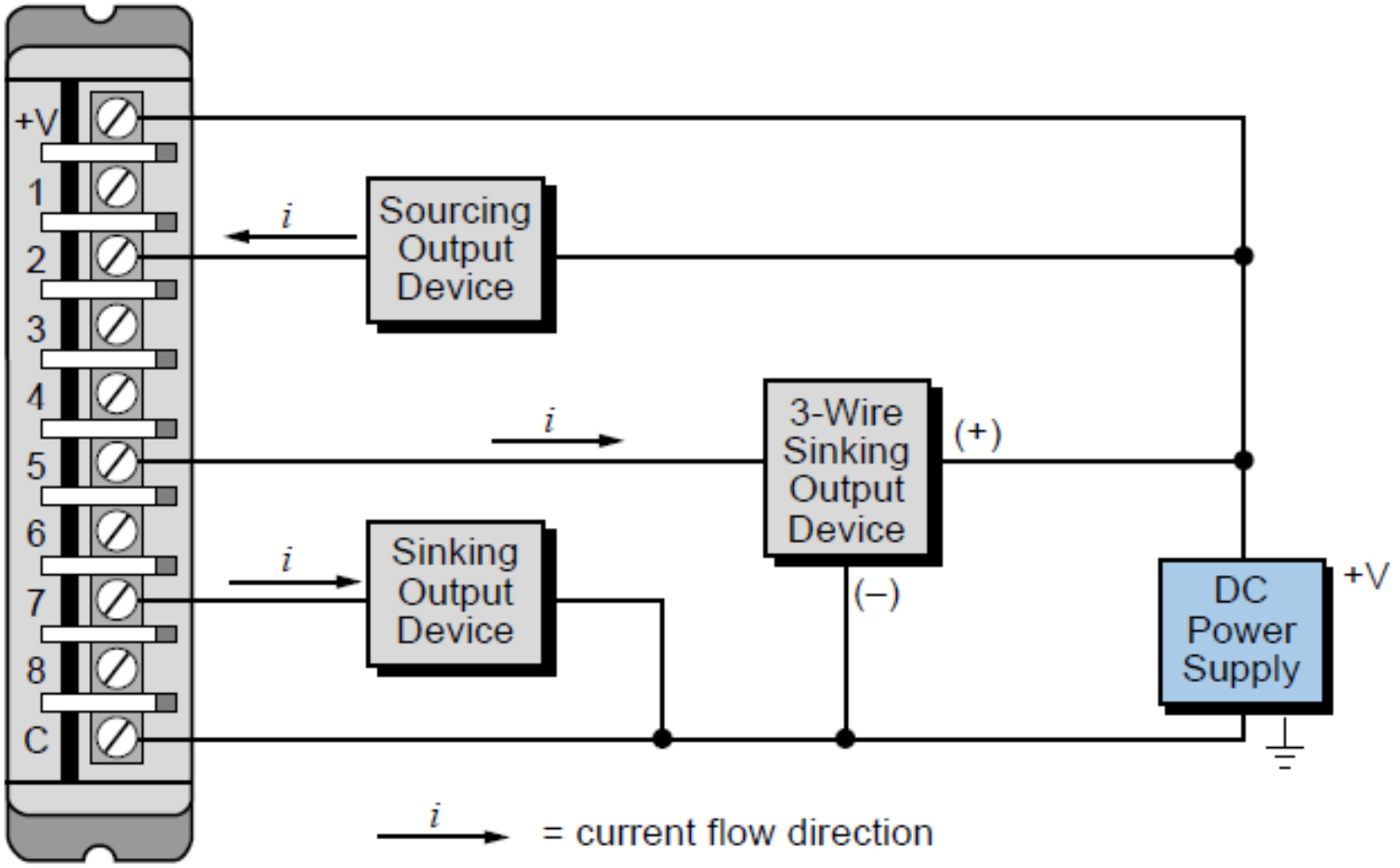

L1
L2
L1
1
2
3
4
MS
C


Output
Module
L1
"Switch"
controlled by
processor
Load
Output
Field
Device
L2

# AC Outputs

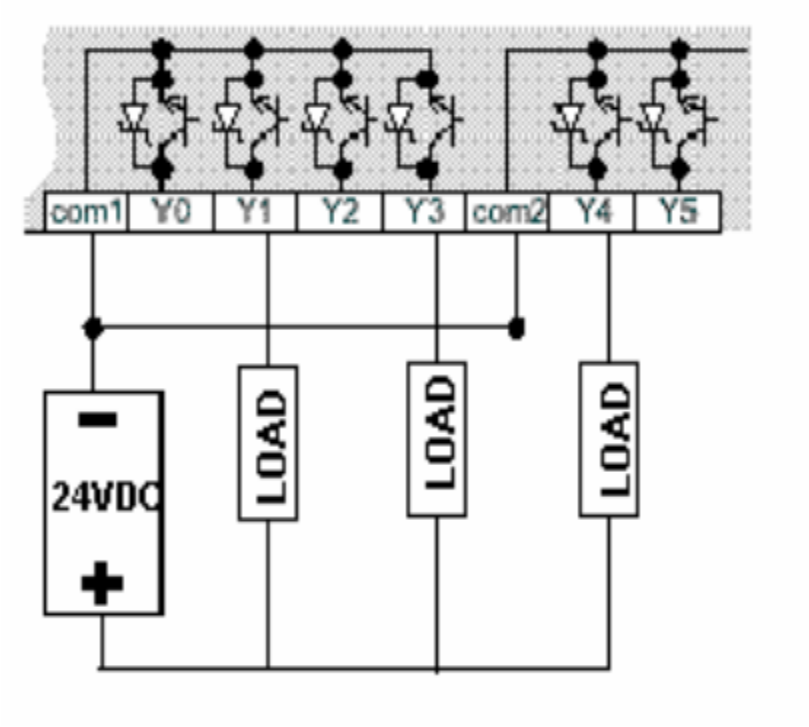


# DC Outputs – Sink/Source

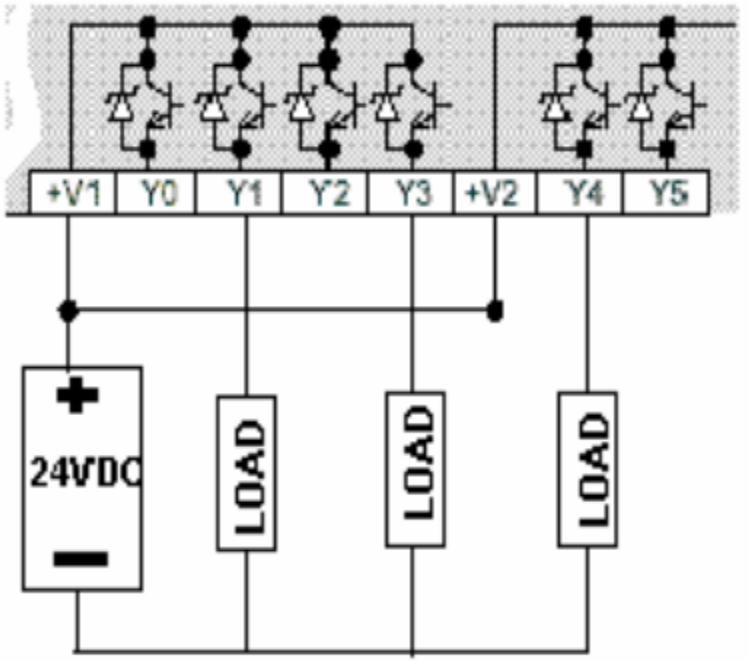


# DC Outputs - PLC (Mitsubishi) Wiring

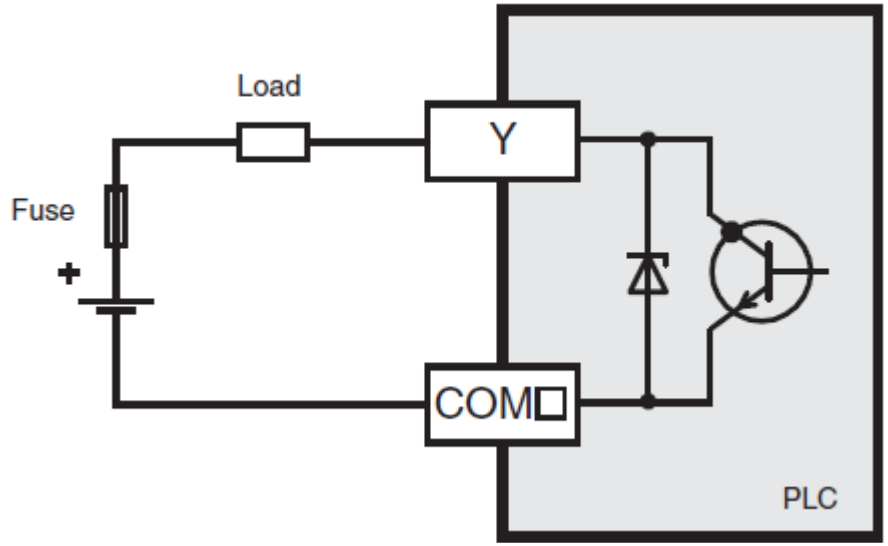
## Sinking Outputs



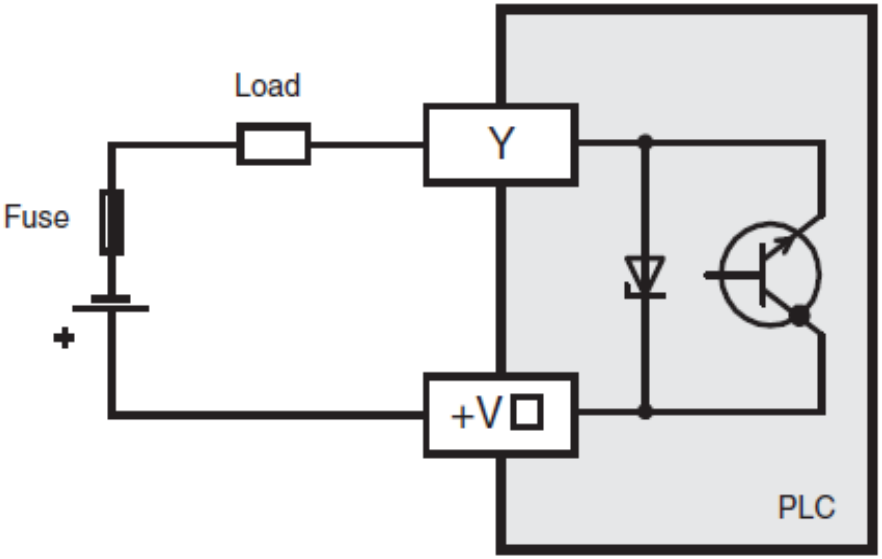

## Sourcing Outputs



# DC Outputs - PLC (Mitsubishi) Wiring



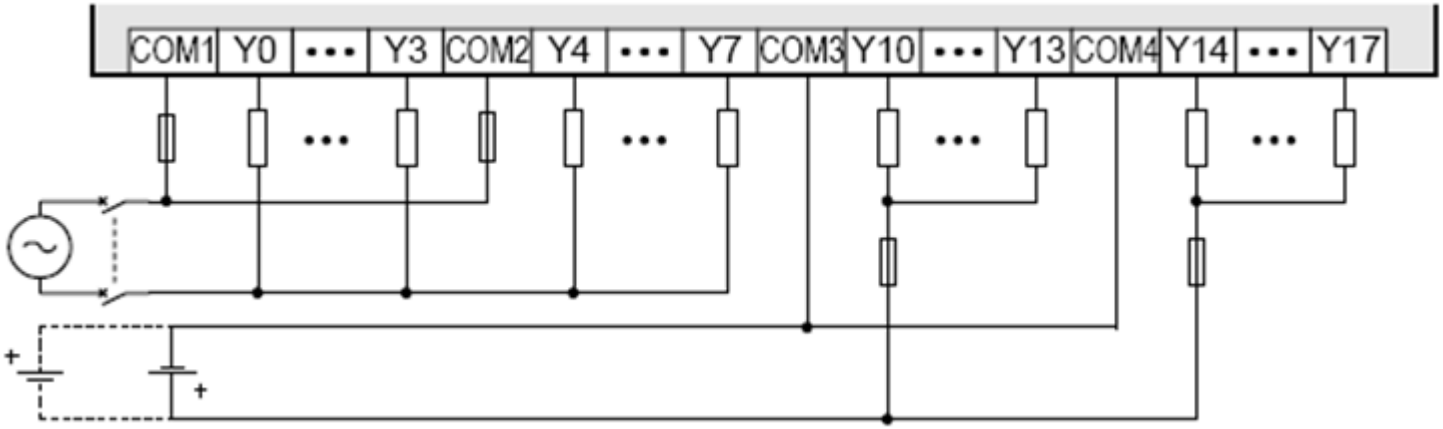

Transistor Output (**Sink**)

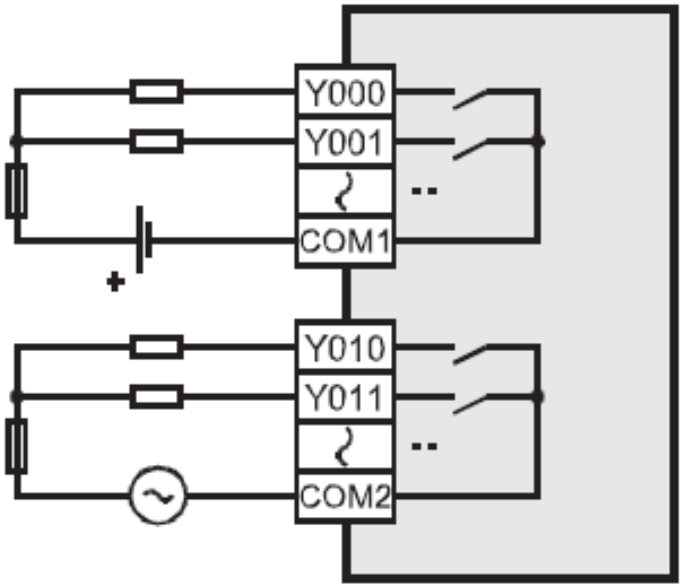



Transistor Output (**Source**)

# Contact Outputs - PLC (Mitsubishi) Wiring

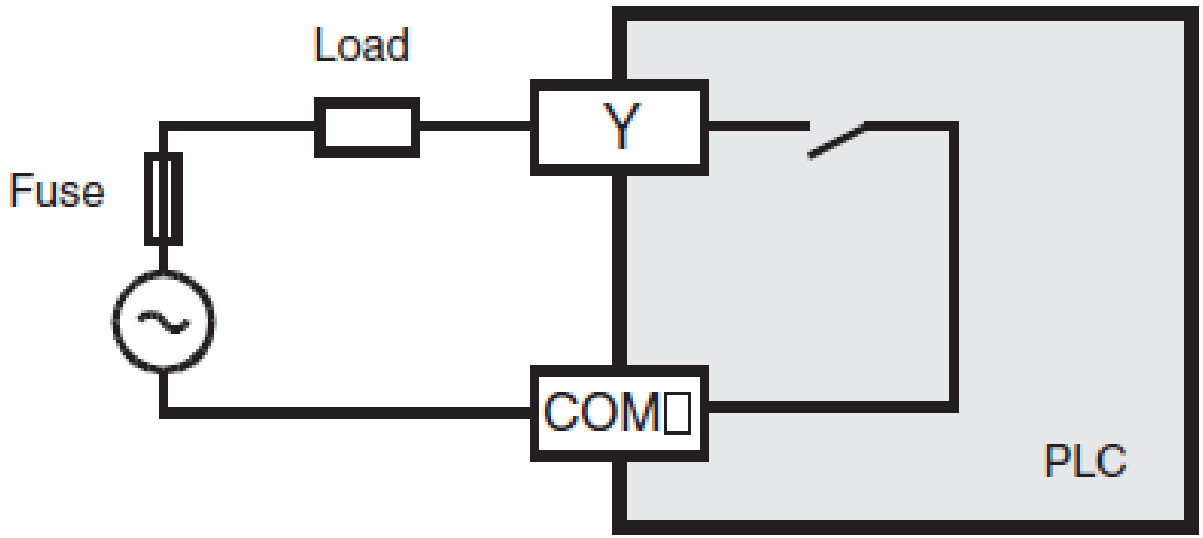
- Digital Outputs



# Contact Outputs - PLC (Mitsubishi) Wiring

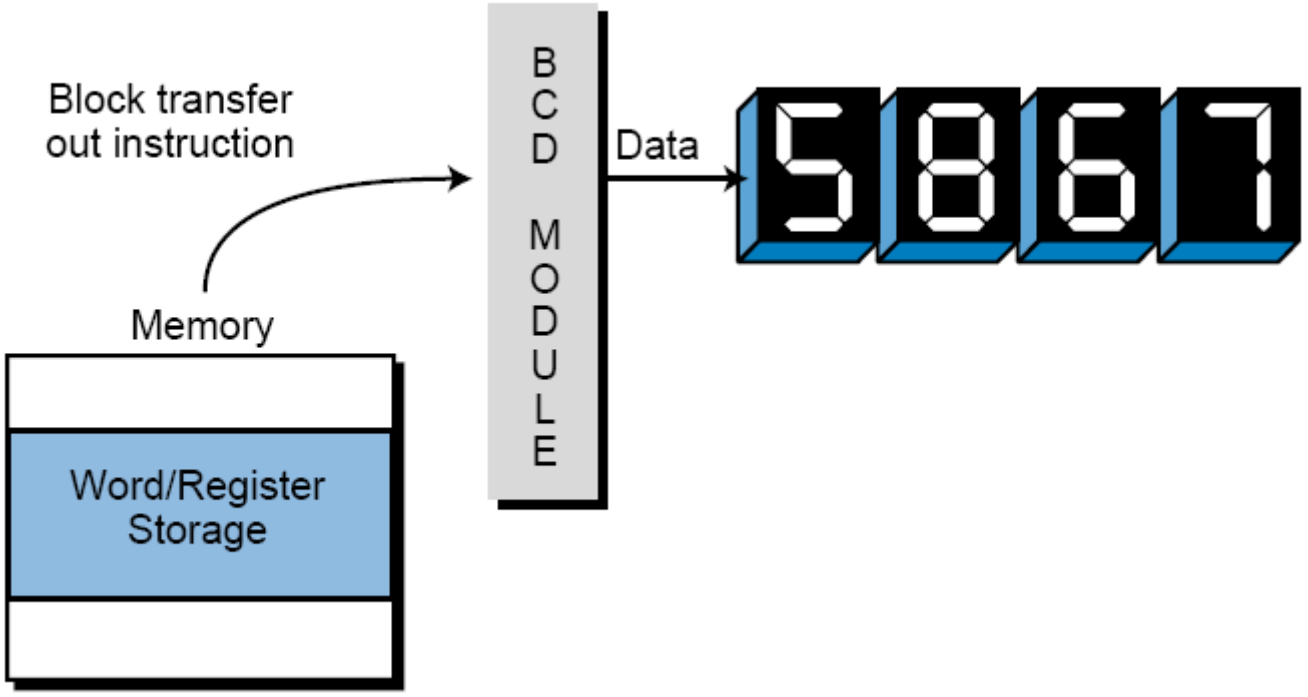
Relay output



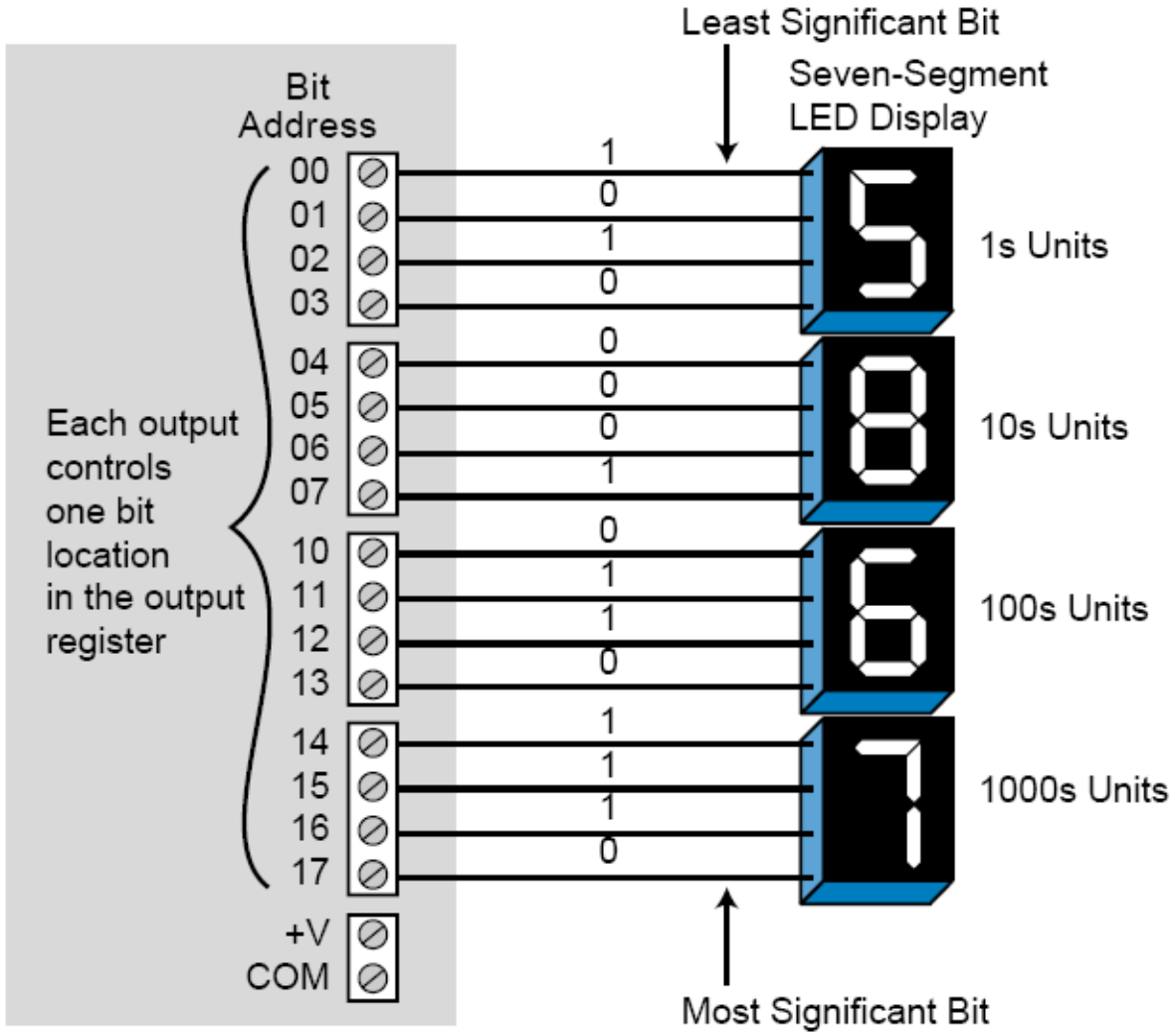
# Quiz

- Given components and digital output with specific type as following, draw the connection:
  - 1 DC motor sink (device) wiring
  - 1 Light source (device) wiring
  - 1 Solenoid AC power actuating
  - 1 Three phases AC motor

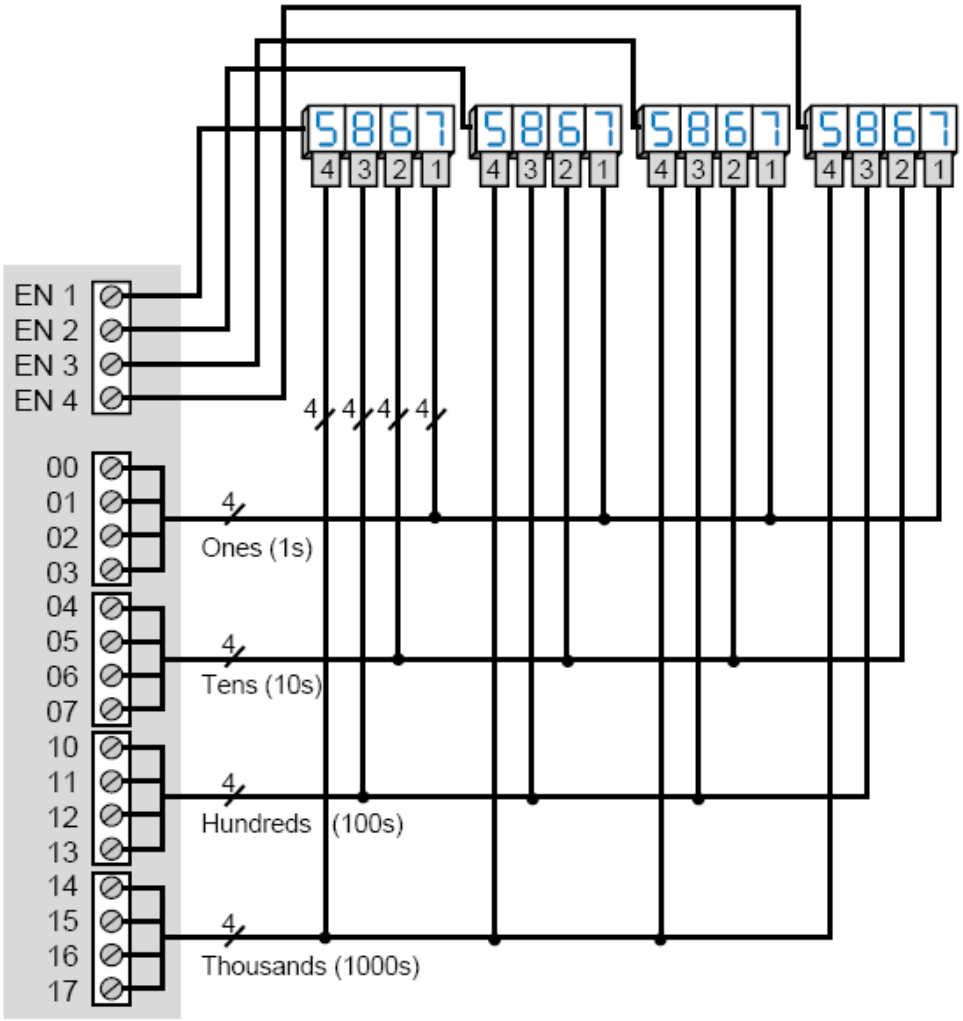
# Register/BCD Outputs



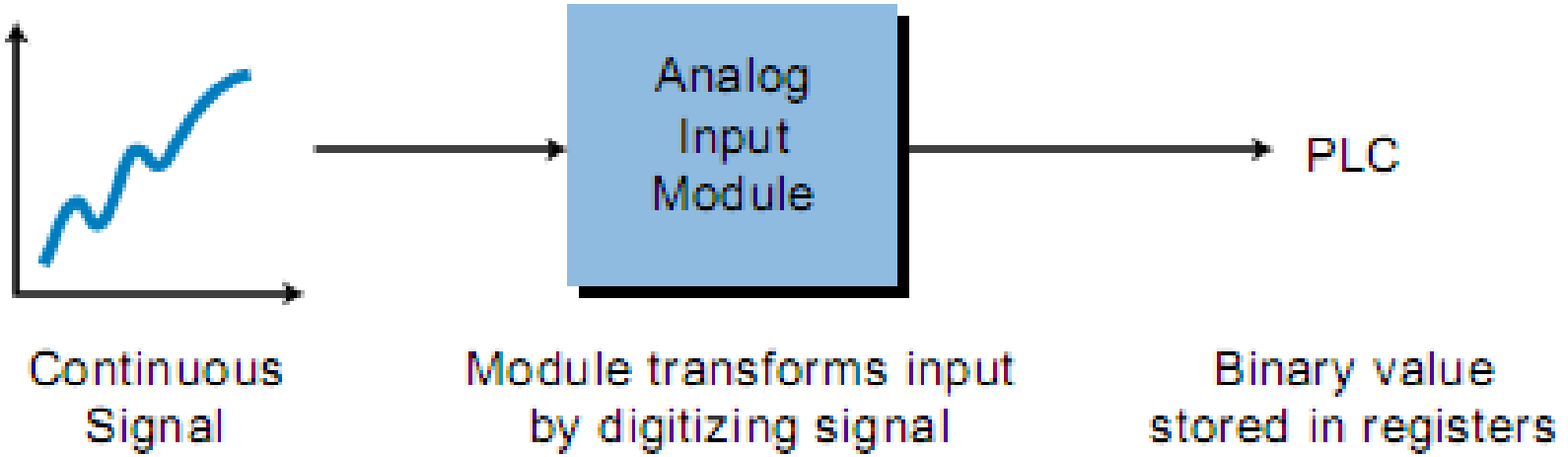
# Register/BCD Outputs



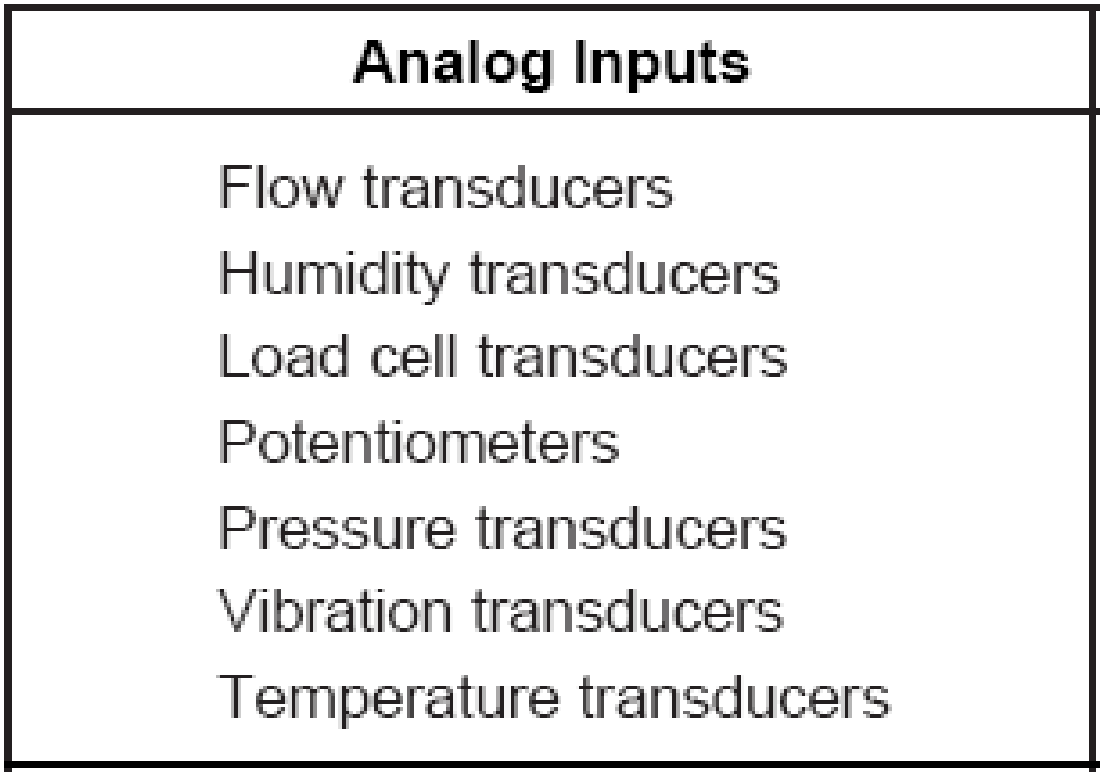
# Register/BCD Outputs



# Analog Inputs



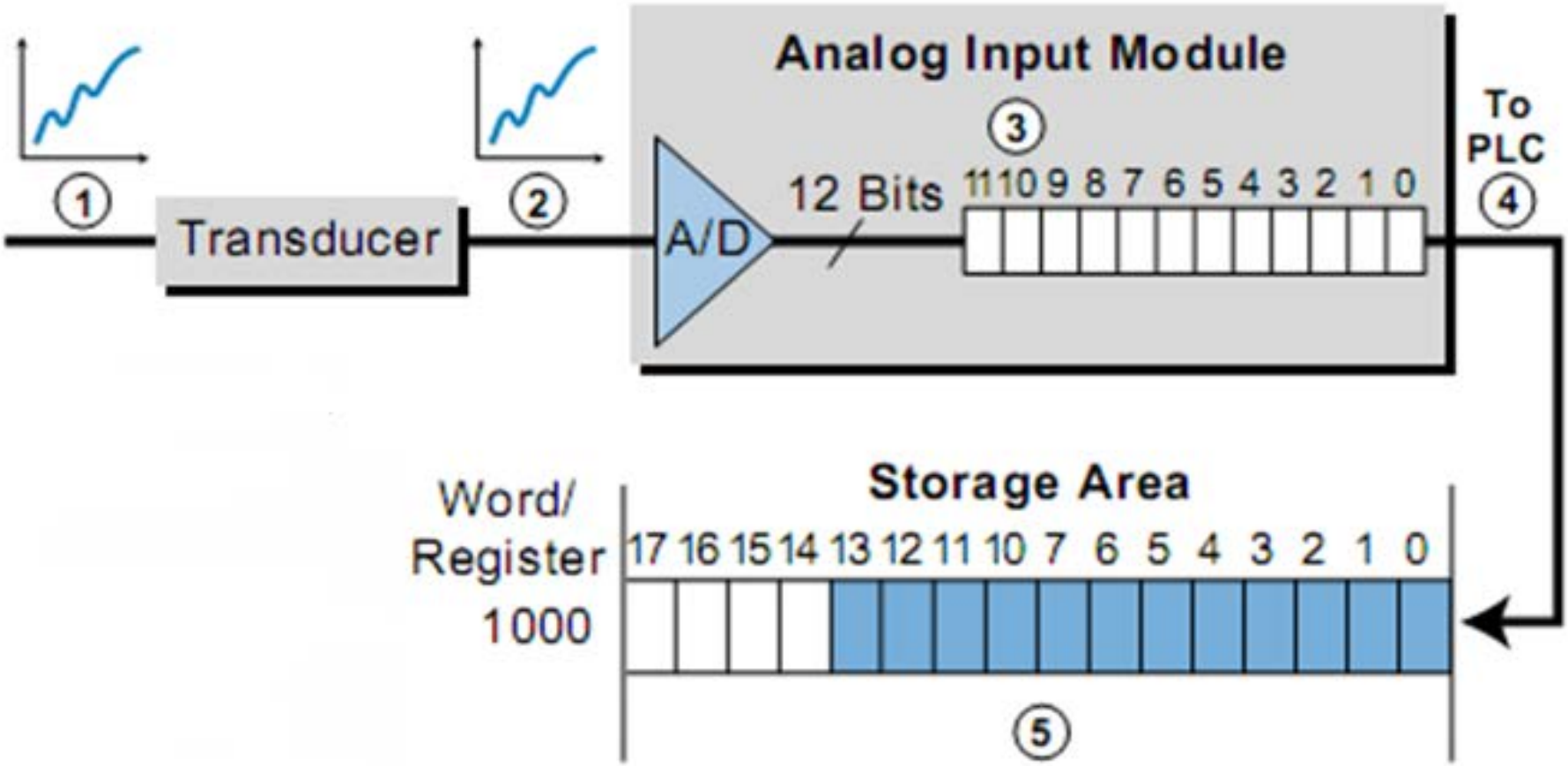
# Analog Inputs



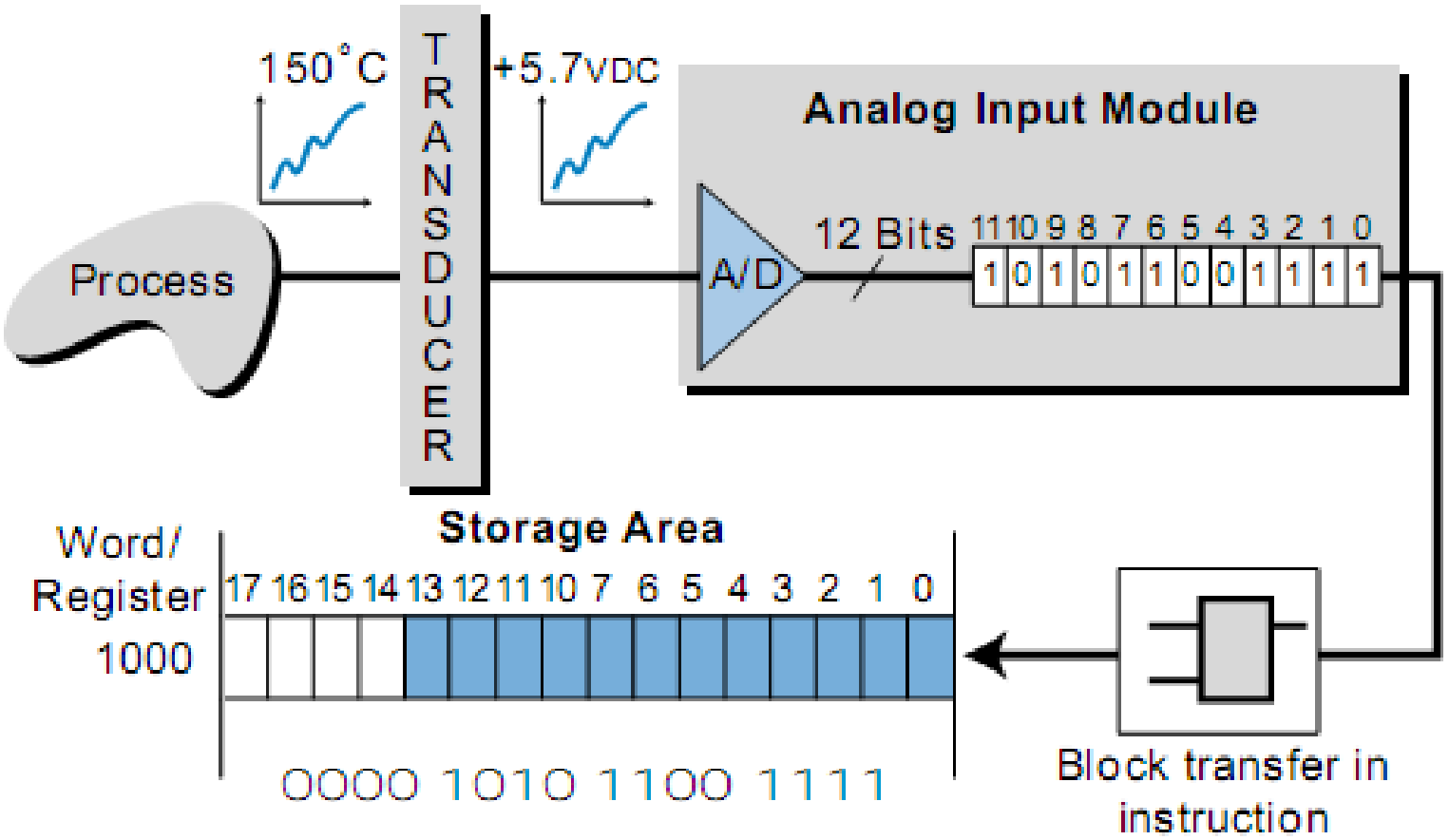
# Analog Devices


# Analog Inputs


# Analog Inputs



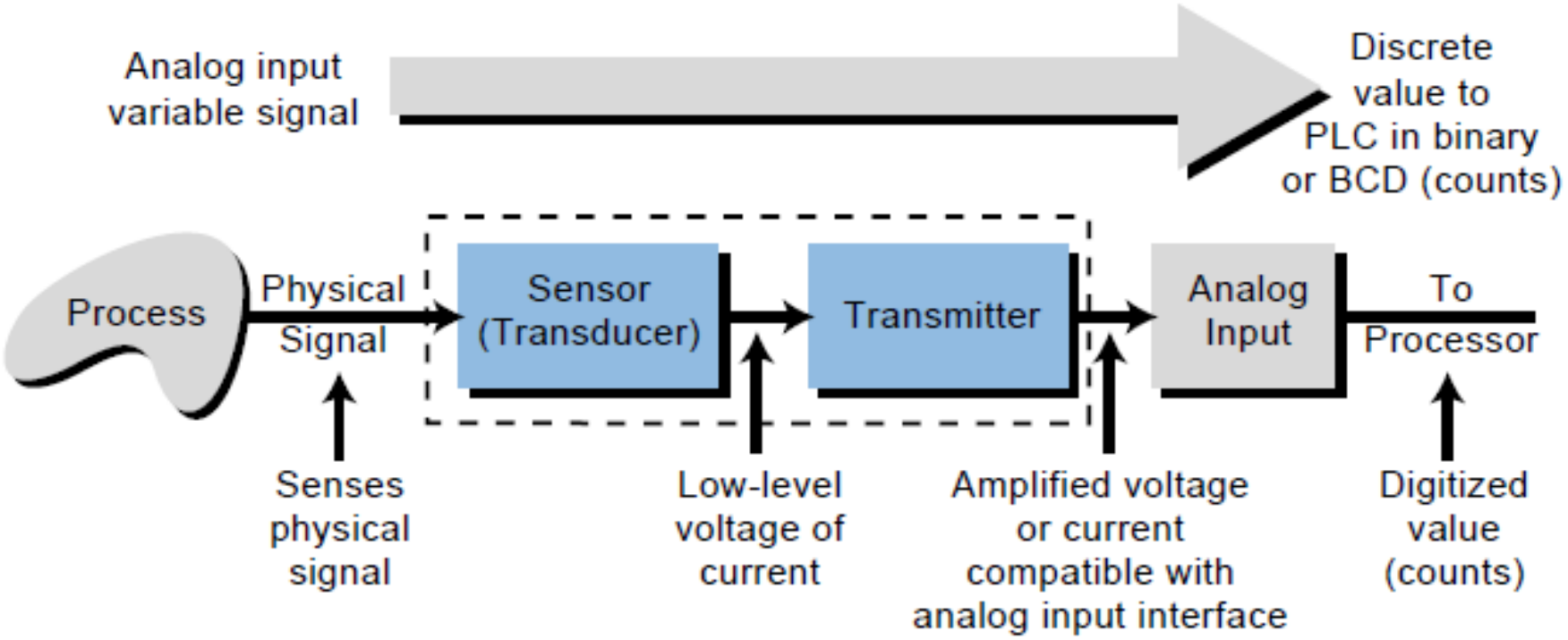
# Analog Inputs



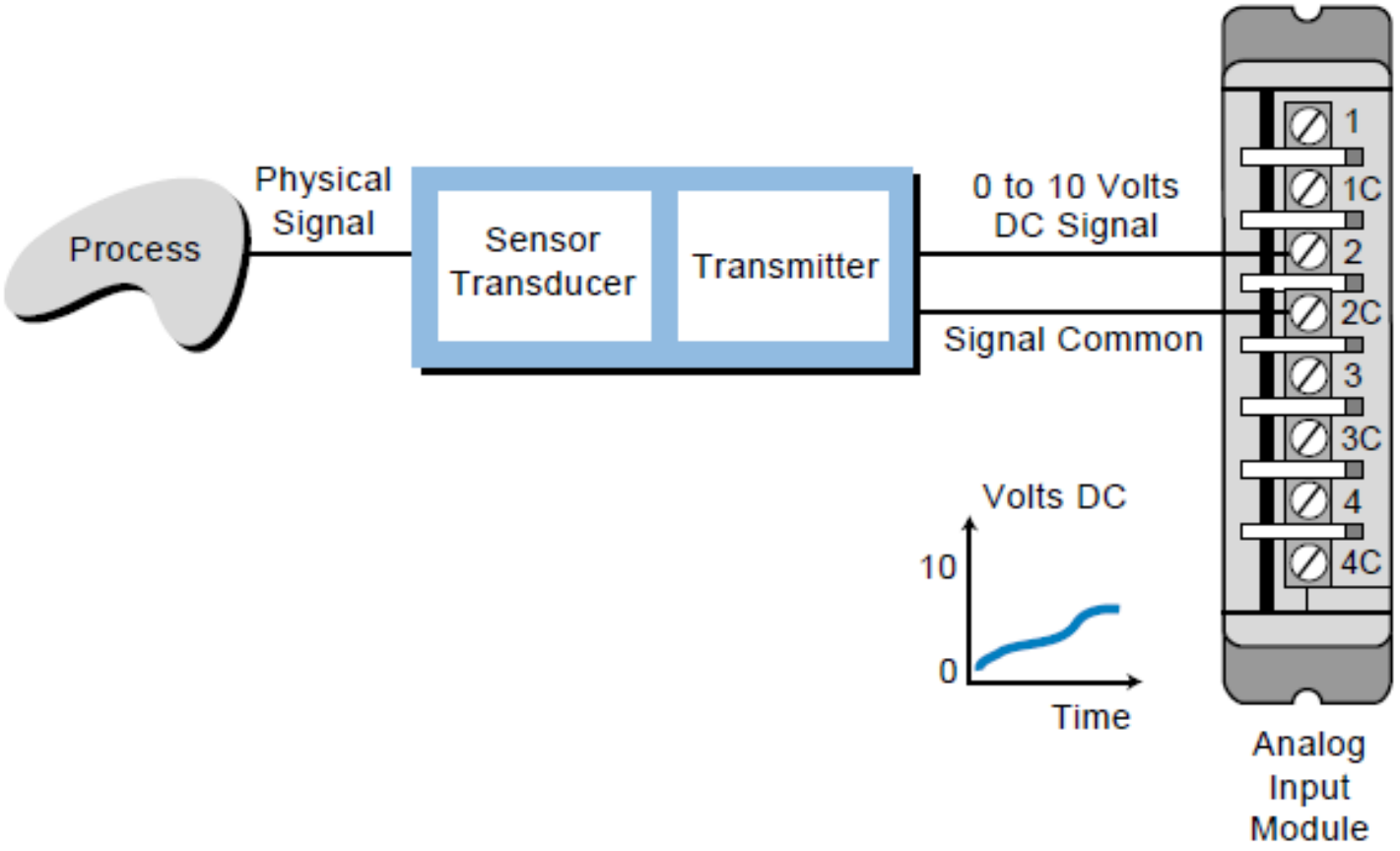
# Analog Inputs

| Input Interfaces |
| --- |
| 4–20 mA |
| 0 to +1 volts DC |
| 0 to +5 volts DC |
| 0 to +10 volts DC |
| 1 to +5 volts DC |
| ± 5 volts DC |
| ± 10 volts DC |

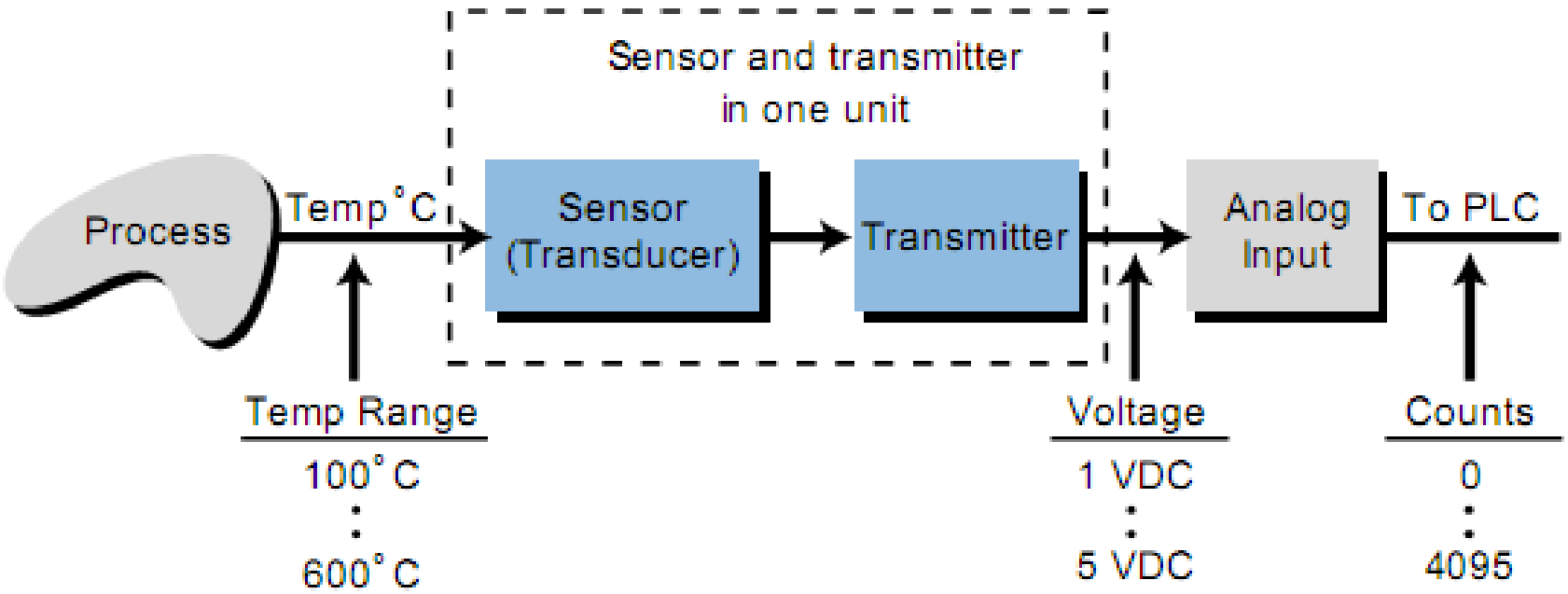
# Analog Inputs



# Analog Inputs



# Analog Inputs



# Analog Inputs

- A/D 12-bit resolution

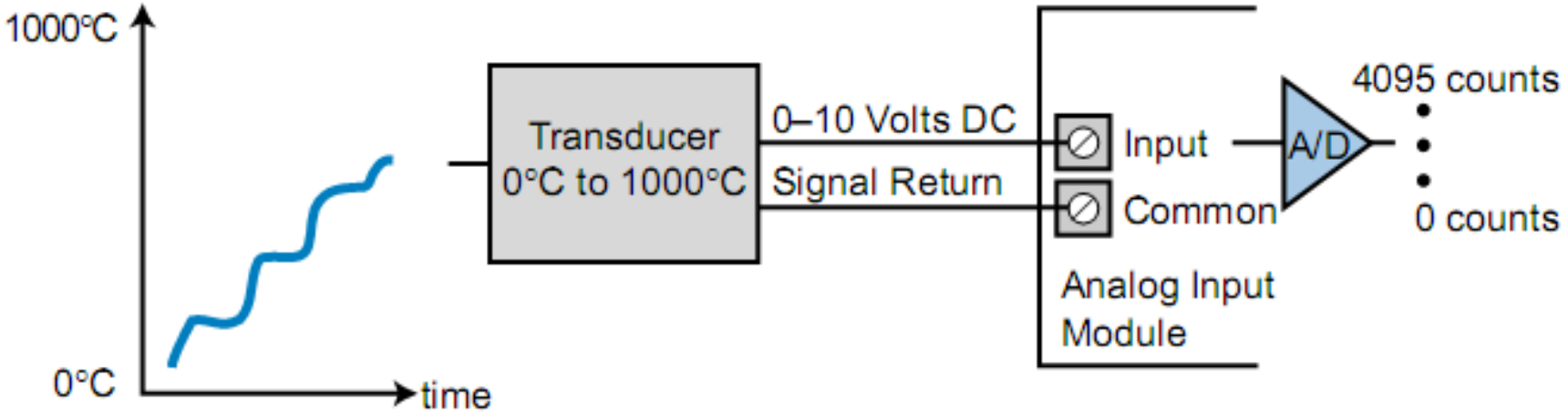
| Temperature | Voltage Signal | Input Counts |
|---|---|---|
| 100°C | 1 VDC | 0 |
| • | • | • |
| • | • | • |
| • | • | • |
| 600°C | 5 VDC | 4095 |

# Analog Inputs

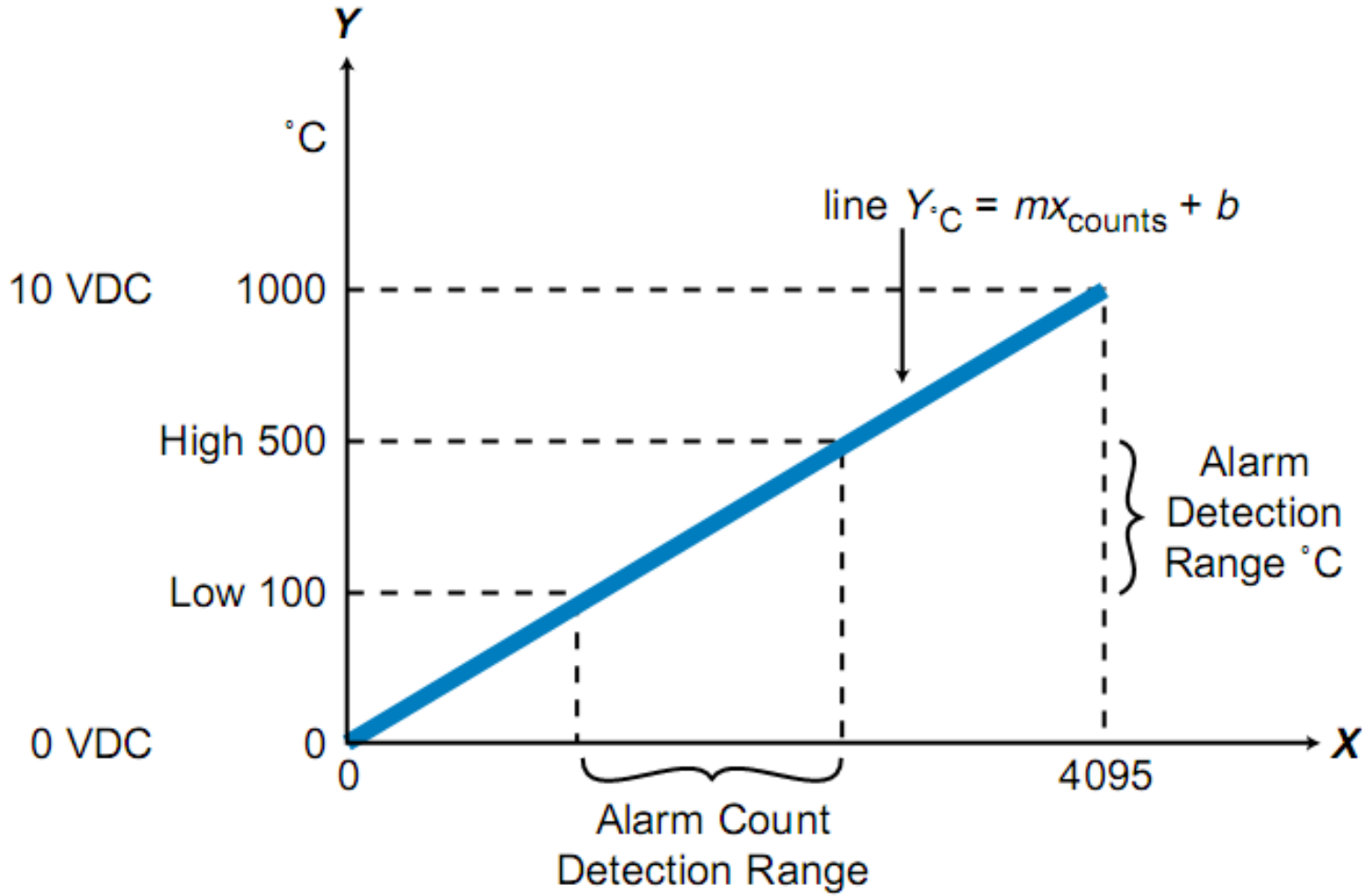
- A/D 10-bit resolution

| Temperature | Voltage Signal | Input Counts |
|---|---|---|
| 100°C | 1 VDC | 0 |
| • | • | • |
| • | • | • |
| • | • | • |
| 500°C | 4 VDC | 1024 |

# Analog Inputs

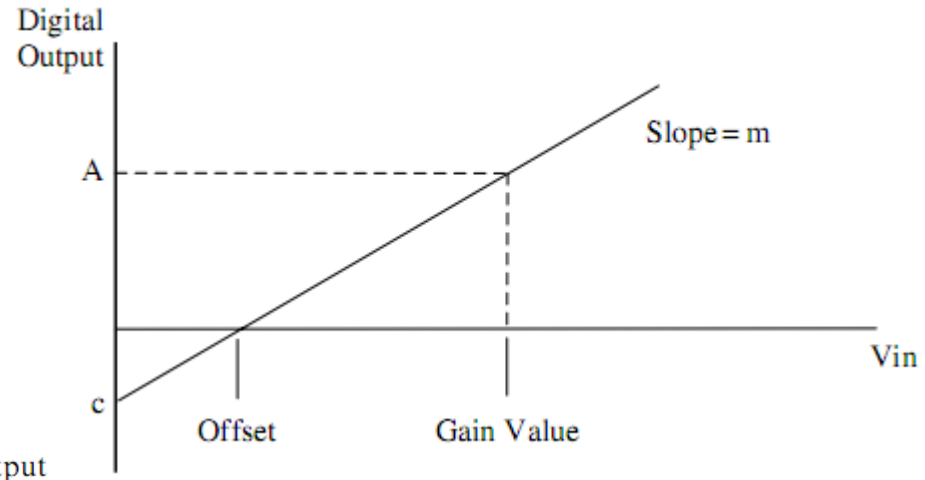


# Analog Inputs



# How to determine coefficients of the linear equation

- **y=mx+c**




**Slope – m**

$$\text{The slope of the ADC graph (m)} = \frac{\text{Change in digital output}}{\text{Change in input voltage}}$$

$$m = \frac{A}{\text{Gain value} - \text{Offset}}$$

**Constant – c**

The constant c is obtained from

$$\text{Slope} = \frac{c}{\text{offset}}$$

From the graph it can be seen that if the Offset is a positive value, then c must be negative.

$$\text{i.e. } c = -(\text{Slope} \times \text{Offset value})$$

# How to determine coefficients of the linear equation

## Complete equation

Hence using the equation for a straight-line graph, i.e. $y = mx + c$

$$\underset{(y)}{\text{Digital output}} = \underset{(m)}{\text{Slope}} \times \underset{(x)}{\text{Vin}} - \underset{(\ c\ )}{\text{Slope} \times \text{Offset}}$$

$$= \text{Slope} \times (\text{Vin} - \text{Offset})$$

$$= \frac{\text{A}}{\text{Gain value} - \text{Offset}} \times (\text{Vin} - \text{Offset})$$

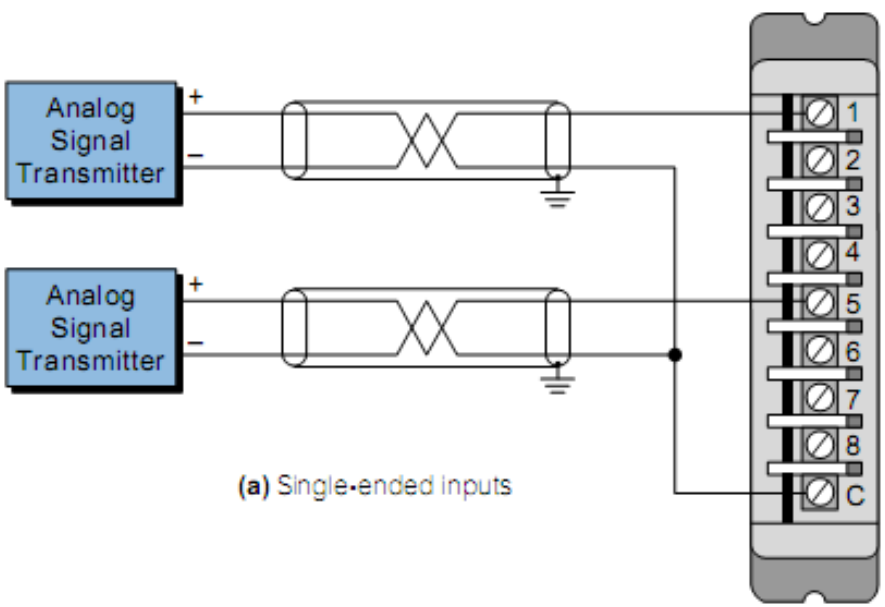
$$\text{Digital output} = \text{A} \times \frac{\text{Vin} - \text{Offset}}{\text{Gain value} - \text{Offset}}$$

# Quiz

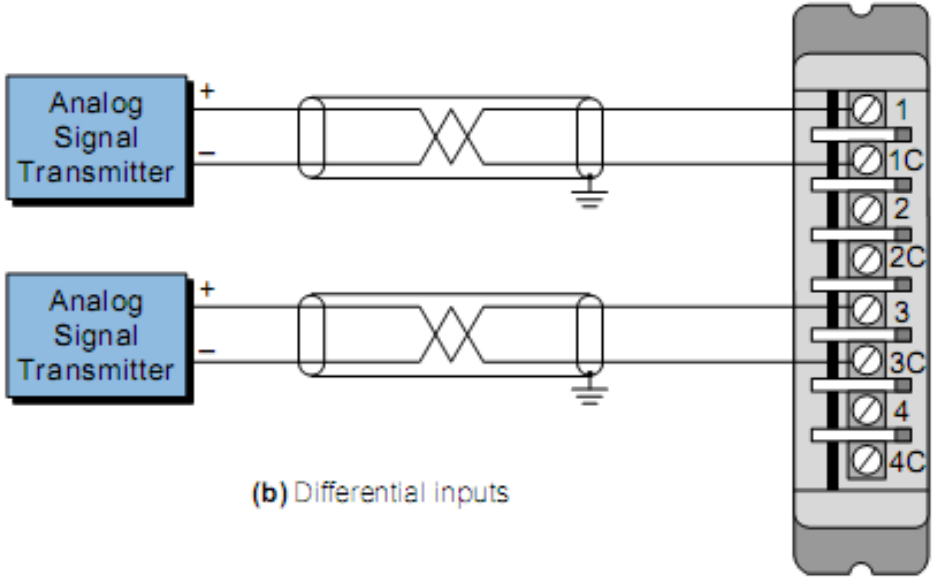
- **Define transfer equation for the following hardware**
  - **Humidity sensor: 0-100%, 0-10VDC; Analog input: 12bit ADC**
  - **Pressure sensor:  0-150 kPa, 4-20 mA; Analog input: 14bit ADC**
  - **Temperature sensor: 0-500 $^0$ C, -10-10 VDC; Analog input: 16bit ADC**

# Analog Inputs

## ❖ Wiring

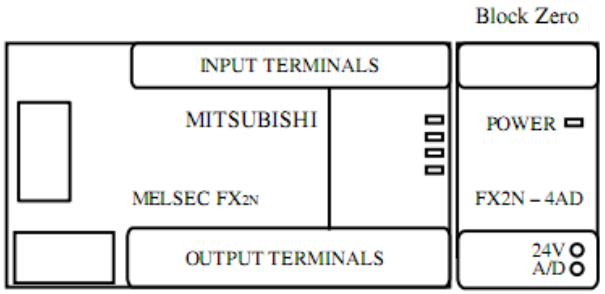


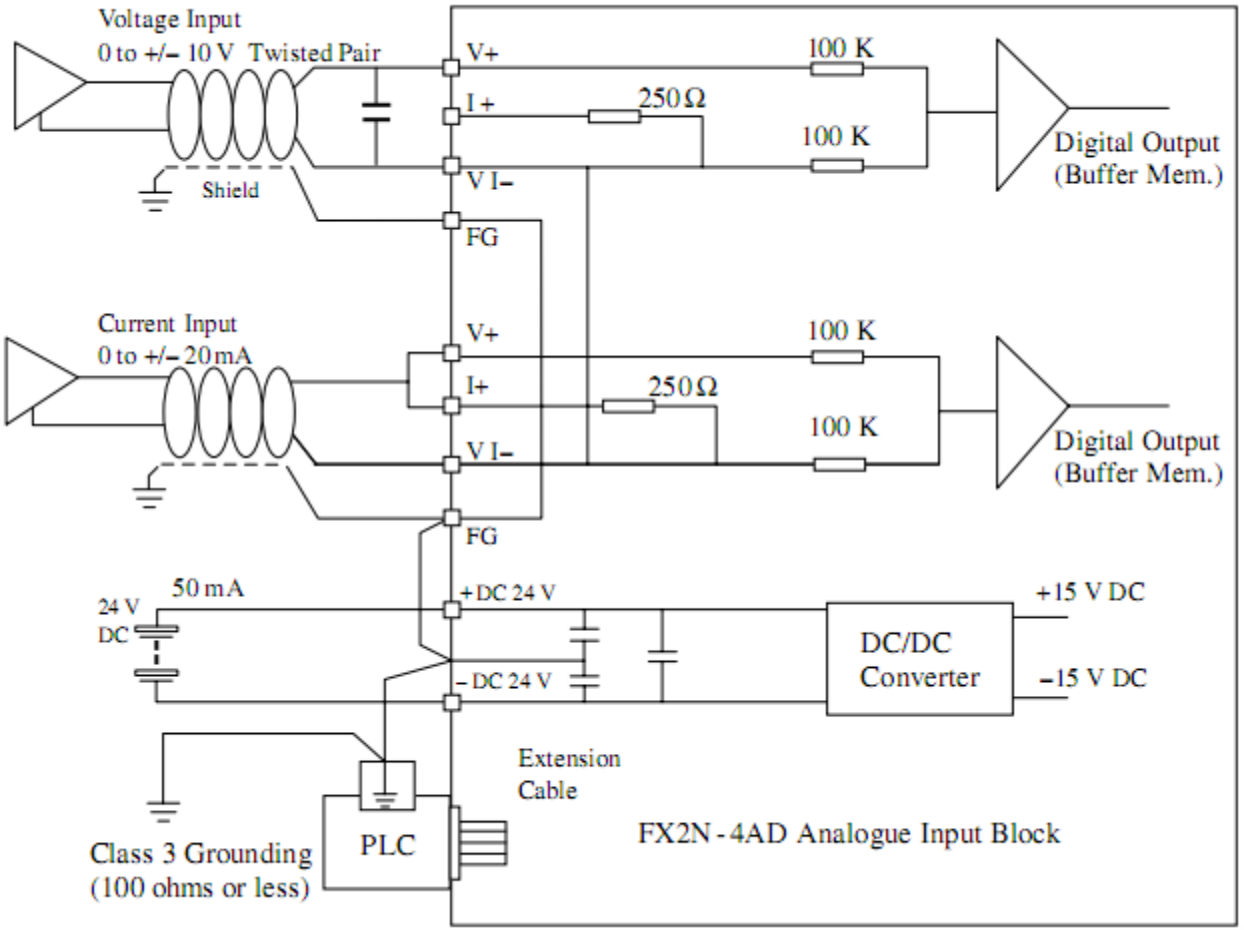

**(a)** Single-ended inputs




**(b)** Differential inputs

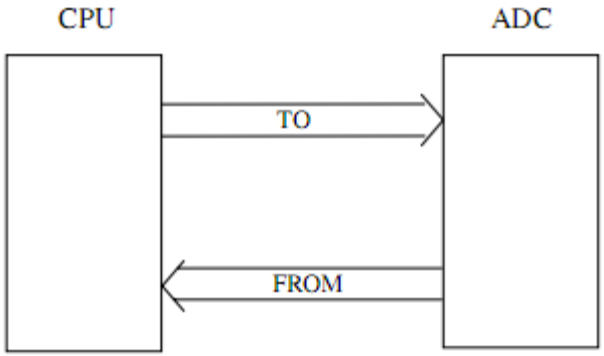
# Analog Module - PLC (Mitsubishi) Wiring



# Allocation of Buffer Memories (BFM)

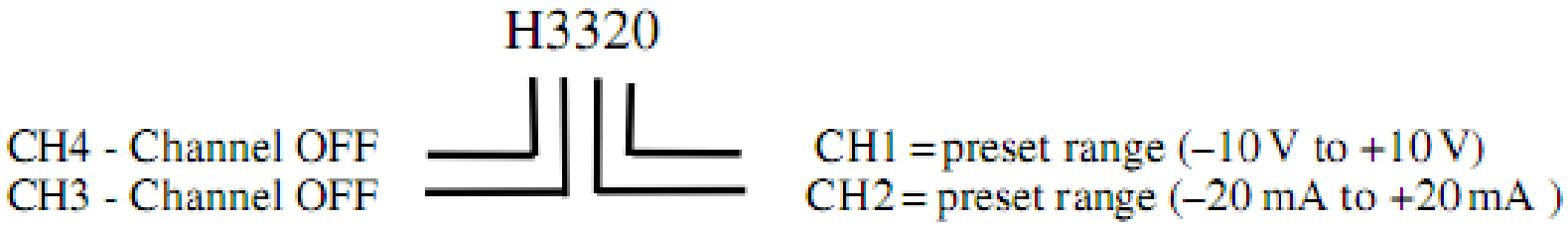
## FX2N – 4AD module




| BFM | Contents |
|---|---|
| *0 | Channel initialisation Default = H0000 |
| *1 | Number of samples for averaging for CH1 (1–4096) Default = 8 |
| *2 | Number of samples for averaging for CH2 (1–4096) Default = 8 |
| *3 | Number of samples for averaging for CH3 (1–4096) Default = 8 |
| *4 | Number of samples for averaging for CH4 (1–4096) Default = 8 |
| 5 | CH1 averaged value |
| 6 | CH2 averaged value |
| 7 | CH3 averaged value |
| 8 | CH4 averaged value |
| 9 | CH1 present value |
| 10 | CH2 present value |
| 11 | CH3 present value |
| 12 | CH4 present value |
| 13–14 | *Reserved for future use* |
| *15 | Conversion Speed 0 = 15 ms per channel 1 = 6 ms per channel |
| 16–19 | *Reserved for future use* |
| *20–24 | Offset/Gain adjustment using software |
| 25–28 | Reserved for future use |
| 29 | Error status |
| 30 | Identification Code (K2010) |
| 31 | *Cannot be used* |

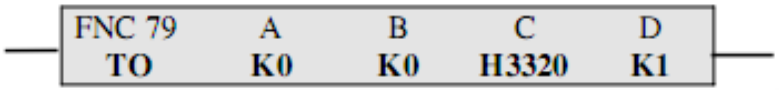
# FX2N – 4AD Configuration

Data value 0: Pre-set range (−10 V to +10 V)
Data value 1: Pre-set range (+4 mA to +20 mA)
Data value 2: Pre-set range (−20 mA to +20 mA)
Data value 3: Channel off.



# FROM – TO Instructions

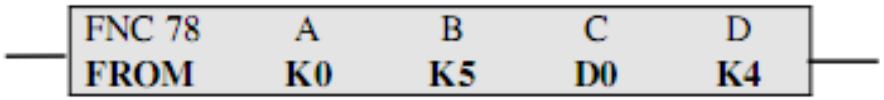
**To**




- **A Block Location** – This is the physical position to the Right Hand Side (R.H.S) of the base unit. For example, if two special units are attached to the PLC, the first will be block 0 (K0), and the second special unit will be block 1 (K1).
- **B Buffer memory area** – This position writes to the required buffer memory location. For example, K0 means that channel initialization data, i.e. H3320 will be transferred to buffer memory 0 (BFM 0).
- **C Data requirements of the FX2N-4AD** – Information in this location is sent to the buffer memory defined in B. In the above example, the data value H3320 is transferred to BFM 0.
- **D Amount of information to be transferred** – This indicates the amount of data to be transferred to the analogue unit. For example, as shown in the example above ‘K1’ indicates that only one word of information, i.e.H3320 is to be transferred to BFM0.

# FROM – TO Instructions

## From




- **A Block Location** – This is the physical position of the unit, to the R.H.S. of the base unit. For example if two blocks are attached to the PLC, the first will be block 0 (K0), and the second block will therefore be block 1 (K1).
- **B Buffer memory area** – This position reads from the required buffer memory location. In the above example, the CH1-converted digital value, which is stored in BFM 5 will be transferred to D0.
- **C Destination of data read by the analogue unit** – In the example shown above, the converted digital output value for CH1 is transferred to data register D0.
- **D Amount of information to be transferred** – This indicates the amount of data to be transferred from the analogue unit. For example as shown in the example above, ‘K4’ indicates that **four words of information** are to be transferred to the PLC.

# FROM – TO Instruction

- **Therefore with just one instruction the following would occur:**
  - **1. The contents of BFM 5 – CH1 – would be transferred to D0.**
  - **2. The contents of BFM 6 – CH2 – would be transferred to D1.**
  - **3. The contents of BFM 7 – CH3 – would be transferred to D2.**
  - **4. The contents of BFM 8 – CH4 – would be transferred to D3.**

# Quiz

- **Given:**
  - Pressure sensor:  0-150 kPa, 4-20 mA; Analog input: 12bit ADC
  - Analog input module at slot 0
  - Sensor is connected to CH1
- **Task:**
  - Draw the connection
  - Define H value
  - Write “To” instruction to configure the analog module
  - Write “From” instruction to read the value from channel 1 and write value to D10

# Reference

- (1) analog input and output modules FX0N-3A The module has two analog input (0 to 10 V DC or 4 to 20 mA DC) channels and one analog output channel. Its resolution digital input channels for eight, and A / D conversion time is 100 μ s, in between analog and digital signals using photoelectric isolation, and applied to FX1N, FX2N, FX2NC-series, occupied eight I / O points.
- (2) Analog Input Module FX2N-2AD the module for 2-way voltage input (0 to 10 V DC, 0 to 5V DC) or current input (4 ~ 20 mA DC), 12 high-precision resolution, the conversion rate is 2.5 ms / channel. This module occupied eight I / O points, applicable to FX1N, FX2N, FX2NC-series.
- (3) Analog Input Module FX2N-4AD The module has four input channels, a resolution of 12. Choice of current or voltage input, users choose wiring to achieve. Optional simulated values for the range of ± 10VDC (resolution of 5 mV), or 4 to 20 mA, -20 ~ 20mA (μ A 20-bit resolution). The highest conversion rate of 6 ms / channel. FX2N-4AD occupied eight I / O points.
- (4) analog output modules FX2N-2DA The module will be 12 for the digital conversion 2:00 analog outputs. Output voltage can be in the form of, for the current. Their choice depends on the different wiring. Voltage output, two analog output channels output signal is 0 to 10 V DC, 0 to 5V DC; current output of 4 to 20 mA DC. Resolution of 2.5 mV (0-10V DC) and 4 μ A (4 ~ 20mA). Digital-to-analog converter features can be adjusted. Conversion rate of 4 ms / channel. The modules occupy eight I / O points. Apply to FX1N, FX2N, FX2N-series.

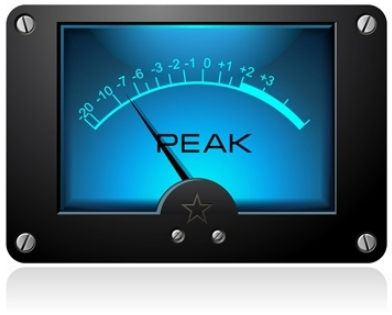
# Reference

- (5) analog output modules FX2N-4DA The module has four output channels. Provide a resolution of 12 high-precision digital input. Conversion rate of 2.1 ms / 4-channel, the use of the channel will not change a few changes in conversion speed. Performance and other similar FX2N-2DA.
- (6) Analog Input Module FX2N-4AD-PT module and the PT100 temperature sensor match will come from the four foil temperature sensor (PT100, 3-wire, 100 Ω) input signal amplification, and data into readable 12 data stored in the host cell. Degrees centigrade and data can be read. Its internal temperature transmitter and analog input circuits, nonlinear sensor can be corrected. Reading a resolution of 0.2 ℃ to 0.3 ℃. Conversion rate of 15 ms / per channel. All the data transmission and parameter settings can be adopted FX2N-4AD-PT software configuration completed by the FX2N TO / FROM Application instructions to achieve. FX2N-4AD-PT occupied eight I / O points can be used to FX1N, FX2N, FX2NC subsystems for the temperature control system to provide more convenient.
- (7) Analog Input Module FX2N-4AD-TC and the thermoelectric module coupling temperature sensor match will come from the four thermal coupling sensor input signal amplification, and data conversion into a 12-readable data stored in the Main Unit, Celsius and Fahrenheit data can be read, read in the type of resolution K at 0.2 ℃; types at 0.3 ℃ J, and K-type (-100 to 1200 ℃) and J-(-100 ~ 600 ℃) supporting the use of thermoelectric coupling, four-channel, using K, or J-conversion rate of 240 ms / channel. All data and parameter settings can be adopted FX2N-4AD-TC software configuration completed, occupied eight I / O points.

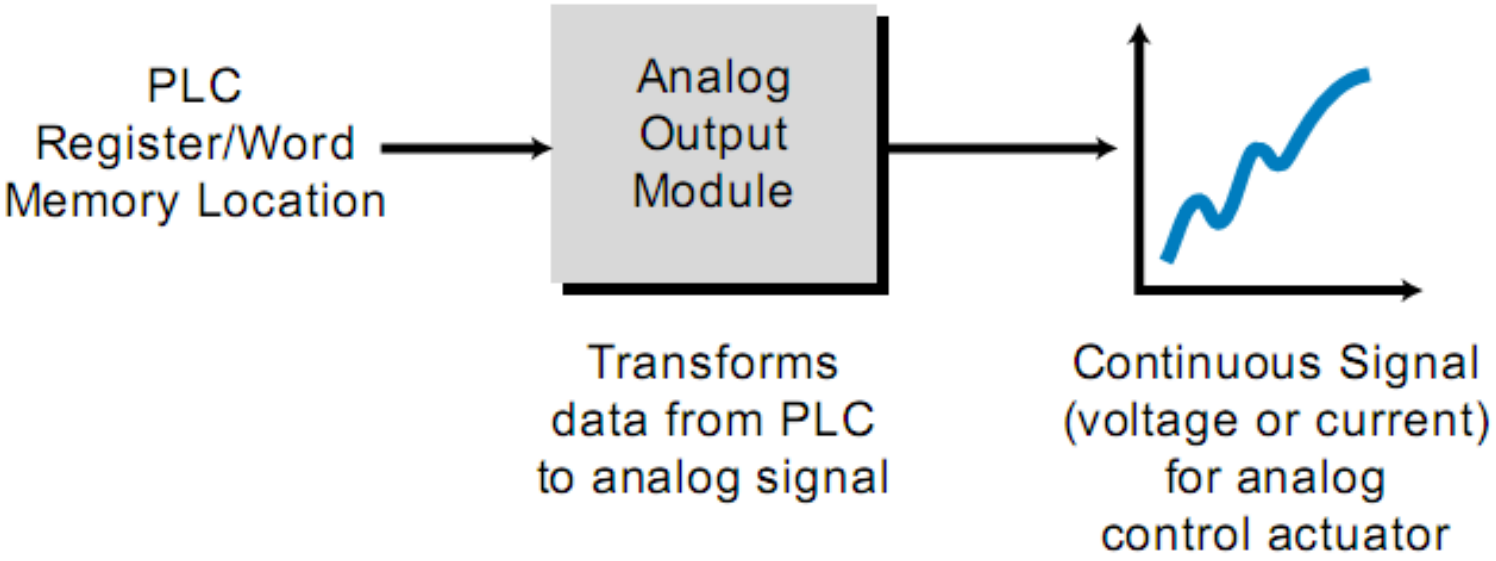
# Analog Outputs

| Analog Outputs |
| --- |
| Analog valves<br>Actuators<br>Chart recorders<br>Electric motor drives<br>Analog meters<br>Pressure transducers |

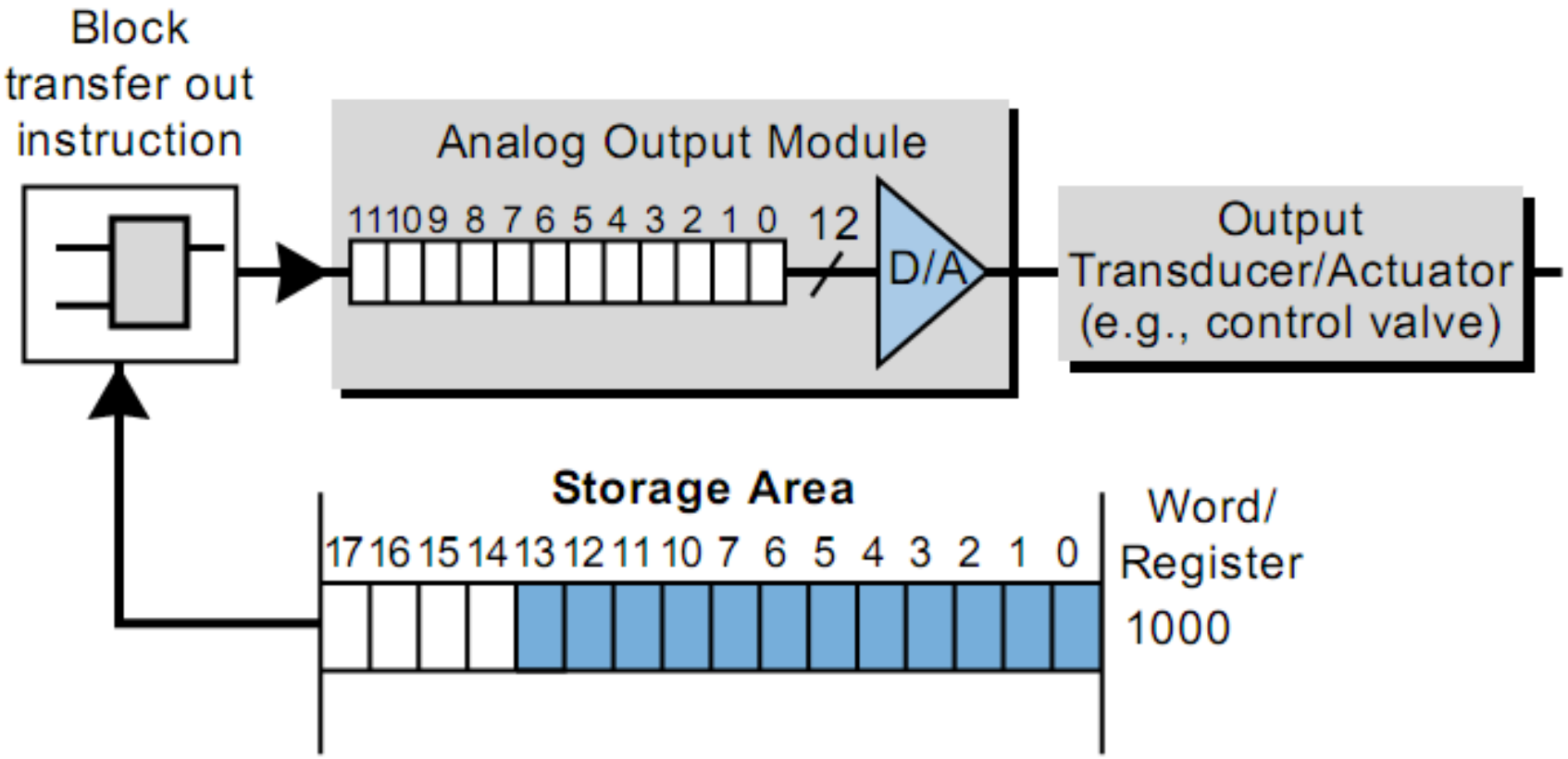
# Analog Devices

# Analog Outputs



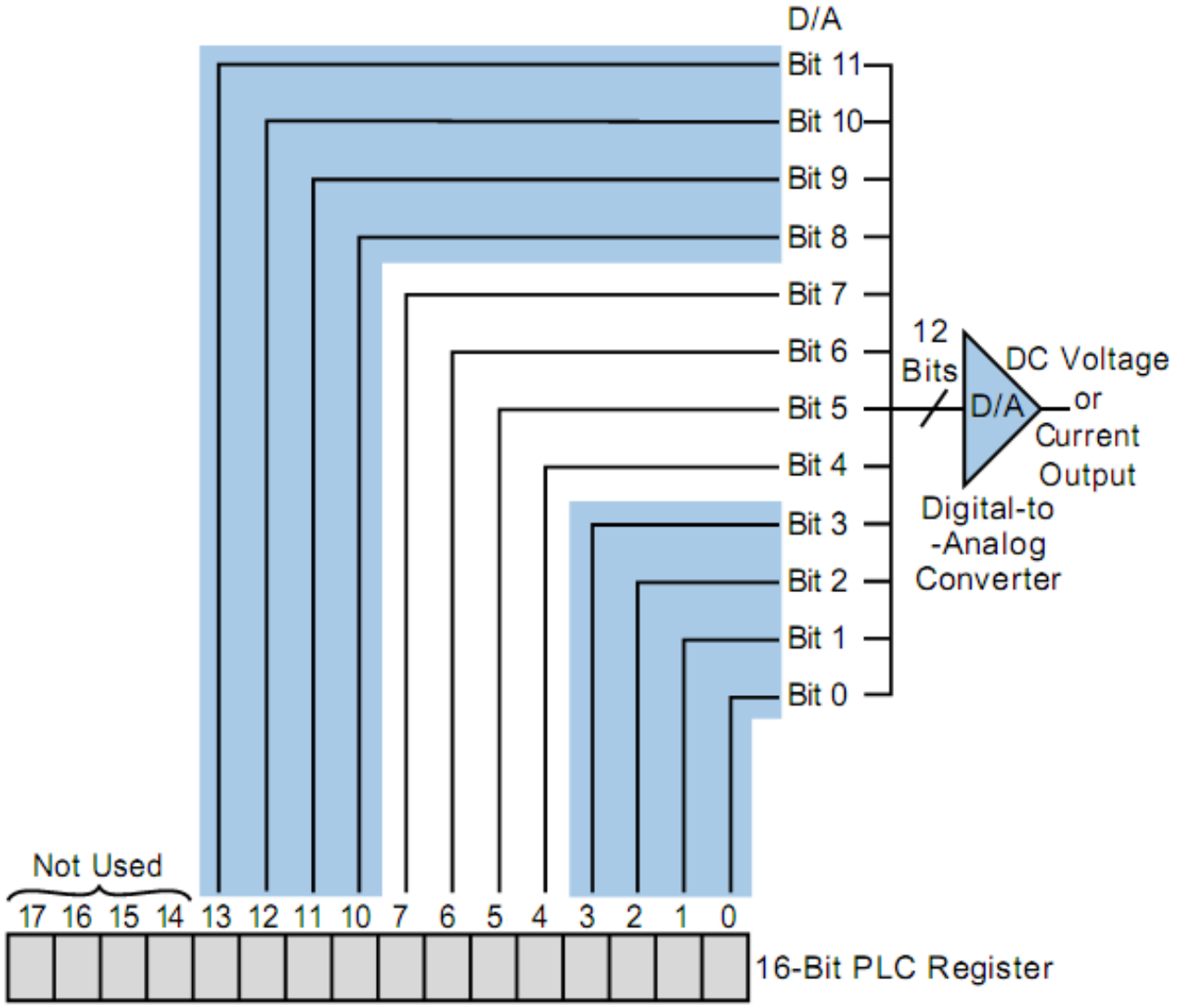
# Analog Outputs



# Analog Outputs

| Output Interfaces |
| --- |
| 4–20 mA |
| 10–50 mA |
| 0 to +5 volts DC |
| 0 to +10 volts DC |
| ± 2.5 volts DC |
| ± 5 volts DC |
| ± 10 volts DC |

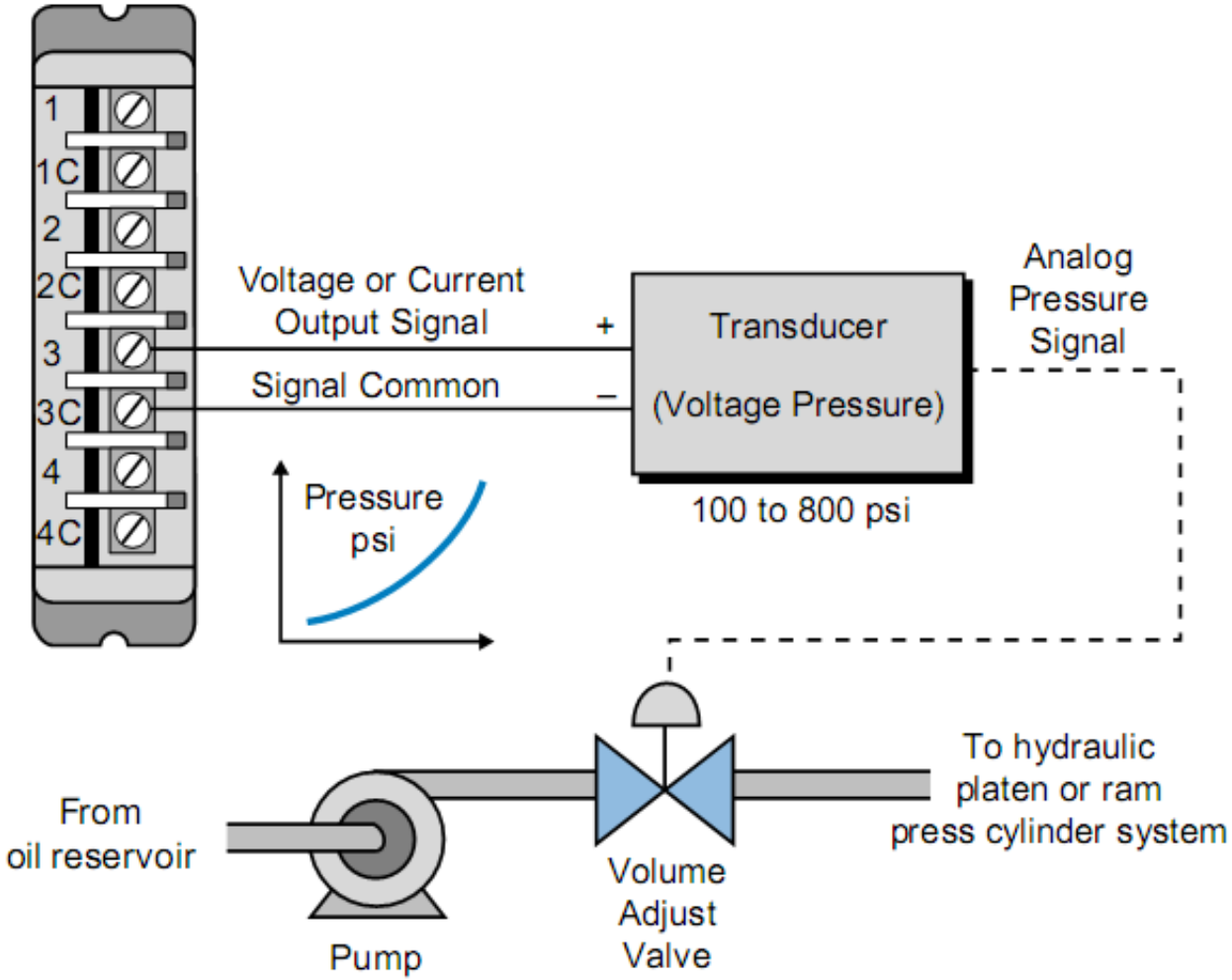
# Analog Outputs



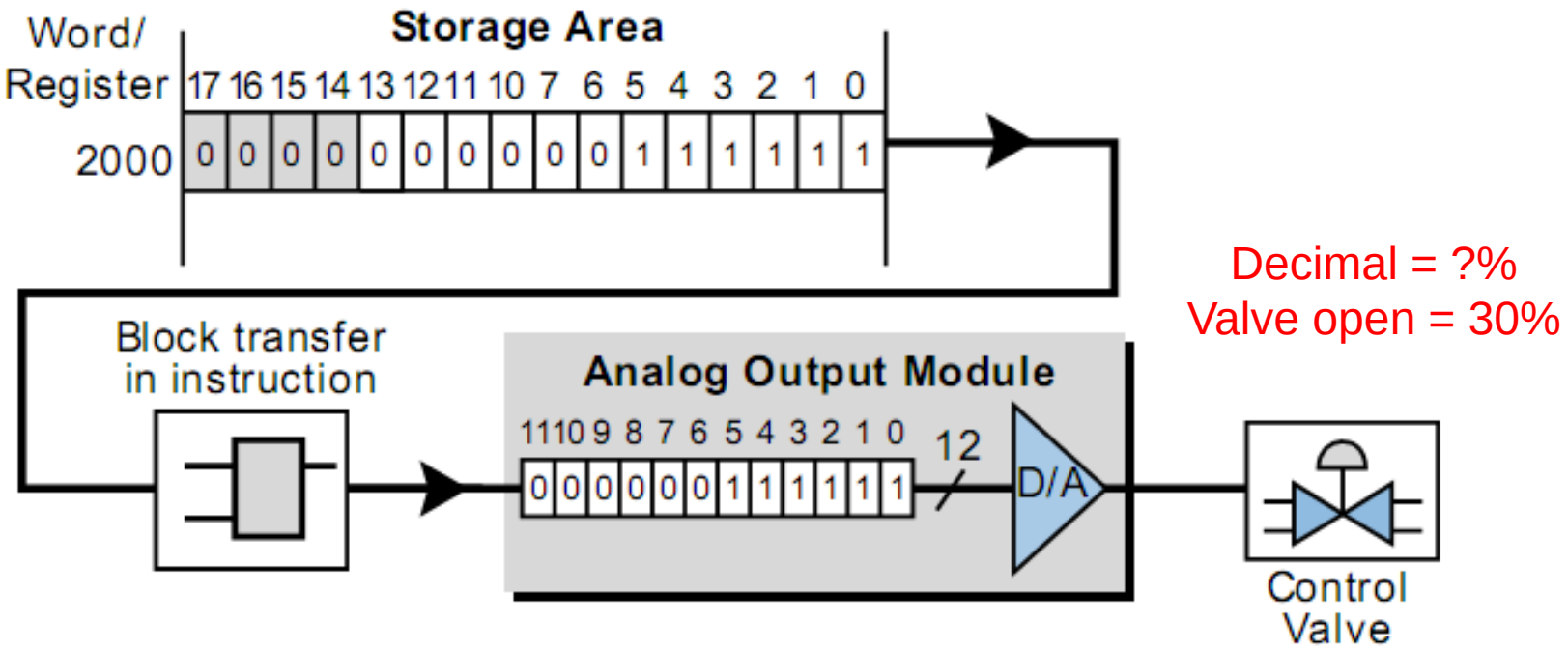
# Analog Outputs

| PLC Register | | Output | | Pressure |
|---|---|---|---|---|
| Decimal | Binary | 0–10 VDC | 4–20 mA | (psi) |
| 0 | 0000 0000 0000 0000 | 0 VDC | 4 mA | 0 psi |
| 2047 | 0000 0111 1111 1111 | 5 VDC | 12 mA | 1000 psi |
| 4095 | 0000 1111 1111 1111 | 10 VDC | 20 mA | 2000 psi |

# Analog Outputs

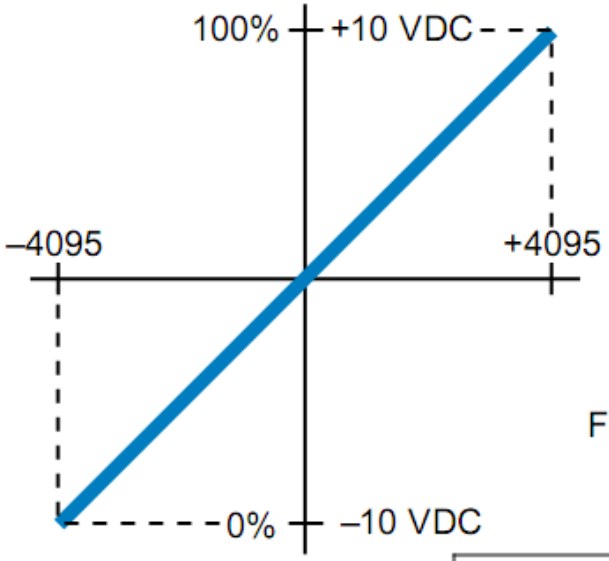


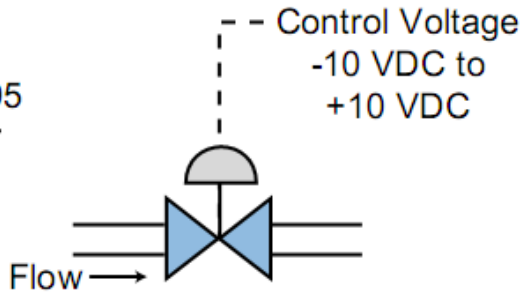
# Analog Outputs




| Decimal | Binary | |
|---|---|---|
| 0 | 0000 0000 0000 | Valve Closed |
| 4095 | 1111 1111 1111 | Full Open |

# Analog Outputs




| ΔPercentage | ΔVoltage (–10 to + 10) | ΔCounts (–4095 to + 4095) |
|---|---|---|
| 100 | 20 | 8190 |

$$1\%\ \text{change as function of voltage} = \frac{20\ \text{VDC}}{100} = 0.2\ \text{VDC}$$

$$1\%\ \text{change as function of counts} = \frac{8190}{100} = 81.90\ \text{counts}$$

# Analog Outputs

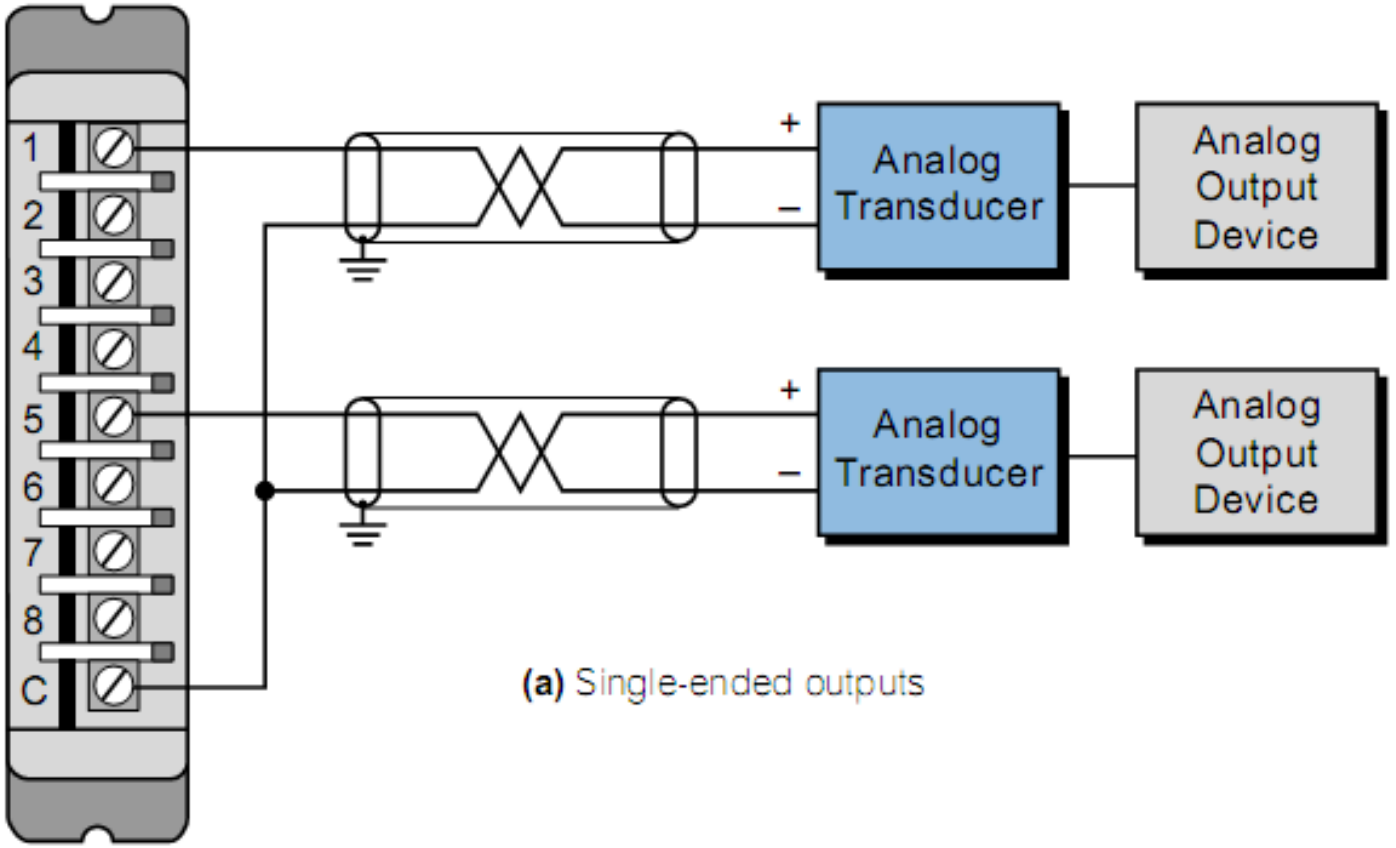
Percentage as function of voltage $= (0.2 \times P) - 10$ VDC

Percentage as function of counts $= (81.9 \times P) - 4095$ counts

| Percentage Opening | Output Voltage | Counts |
|---|---|---|
| 0% | –10 VDC | –4095 |
| 10 | –8 | –3276 |
| 20 | –6 | –2457 |
| 30 | –4 | –1638 |
| 40 | –2 | –819 |
| 50 | 0 | 0 |
| 60 | +2 | +819 |
| 70 | +4 | +1638 |
| 80 | +6 | +2457 |
| 90 | +8 | +3276 |
| 100 | +10 | +4095 |

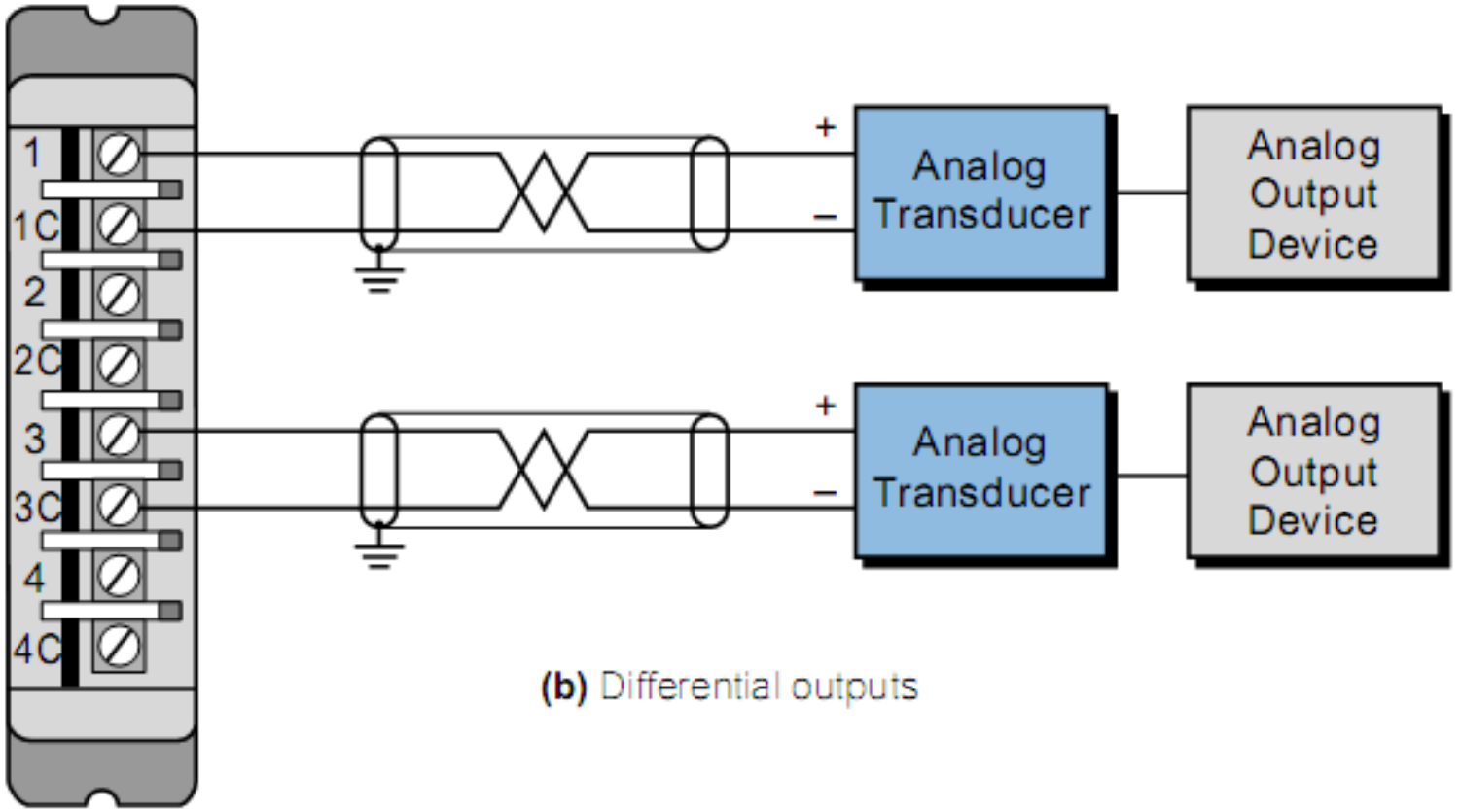
# Analog Outputs

❖ **Phương pháp kết nối**




**(a)** Single-ended outputs

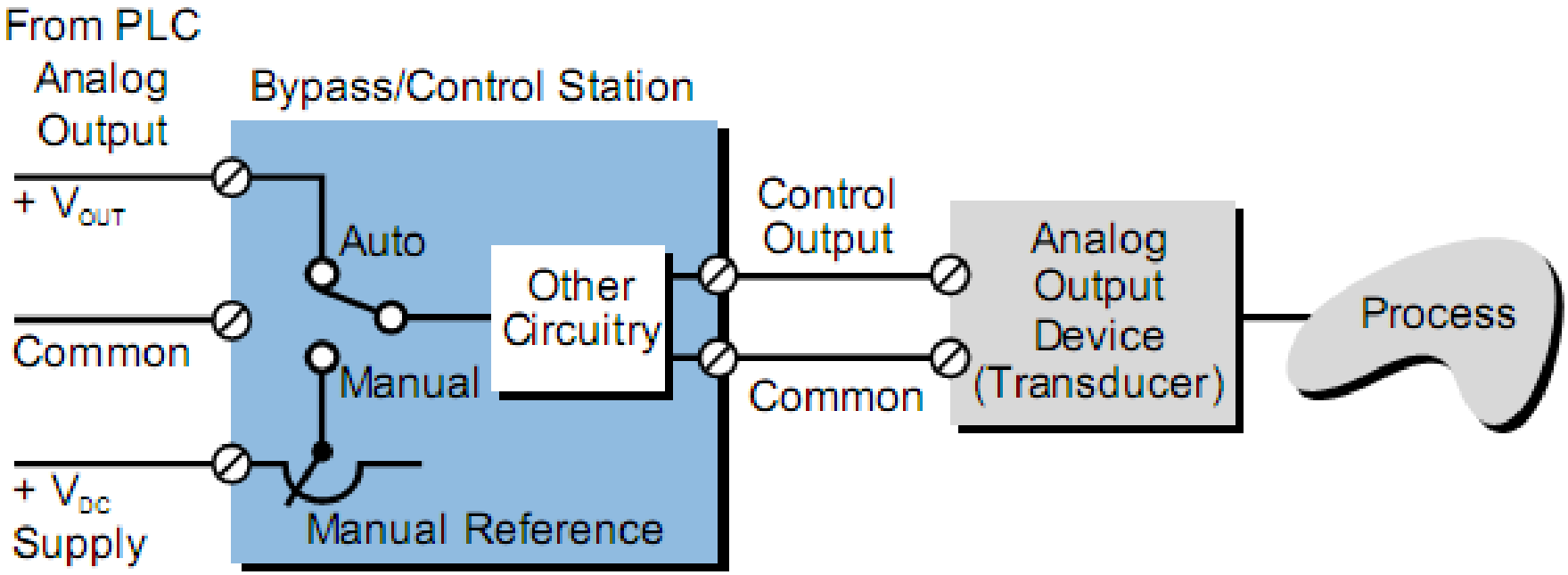
# Analog Outputs




**(b)** Differential outputs

# Analog Outputs

## ❖ Bypass/Control Station



# Allocation of Buffer Memories (BFM)

## FX2N – 4DA module

| | BFM | | Contents | |
|---|---|---|---|---|
| W E | 0 | Output mode select | Factory setting H000 | CH1–CH4 voltage output |
| W | 1 | | CH1 digital input | |
| W | 2 | | CH2 digital input | |
| W | 3 | | CH3 digital input | |
| W | 4 | | CH4 digital input | |
| W E | 5 | Data holding mode | Factory setting | H0000 |
| W | 6 | | Reserved | |
| W | 7 | | Reserved | |
| W E | 8 | CH1–CH2 Offset/gain | Transfer to EEPROM | |
| W E | 9 | CH3–CH4 Offset/gain | Transfer to EEPROM | |

# Allocation of Buffer Memories (BFM)

| | BFM | | Contents | |
|---|---|---|---|---|
| W | 10 | CH1 Offset data | Factory setting | Offset: 0 |
| W | 11 | CH1 Gain data | Factory setting | Gain value: 5000 |
| W | 12 | CH2 Offset data | Factory setting | Offset: 0 |
| W | 13 | CH2 Gain data | Factory setting | Gain value: 5000 |
| W | 14 | CH3 Offset data | Factory setting | Offset: 0 |
| W | 15 | CH3 Gain data | Factory setting | Gain value: 5000 |
| W | 16 | CH4 Offset data | Factory setting | Offset: 0 |
| W | 17 | CH4 Gain data | Factory setting | Gain value: 5000 |
| | 18 | | Reserved | |
| | 19 | | Reserved | |
| W E | 20 | When set to 1 all values return to factory setting | | |
| W E | 21 | 1 Change settings | 2 Inhibit change of settings | |
| | 22 | | Reserved | |
| | 23 | | Reserved | |
| | 24 | | Reserved | |
| | 25 | | Reserved | |
| | 26 | | Reserved | |
| | 27 | | Reserved | |
| | 28 | | Reserved | |
| | 29 | | Error status | |
| * | 30 | K3020 | Identification code – DAC | |
| * | 31 | | Reserved | |

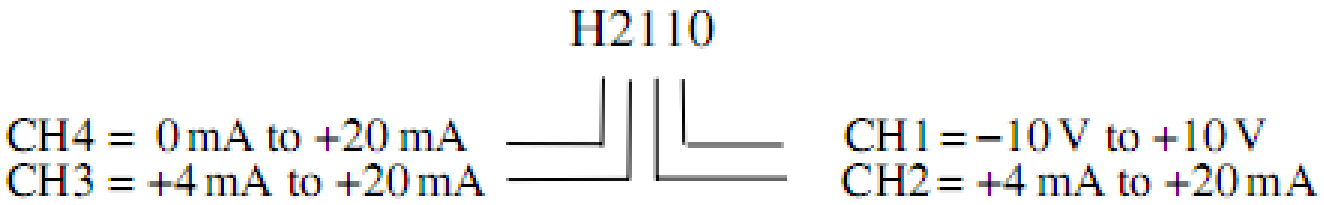
Notes:

W Write to buffer memory
E Data transfer to non-volatile EEPROM
* Read from buffer memory

# FX2N - 4DA Configuration

## Output mode settings

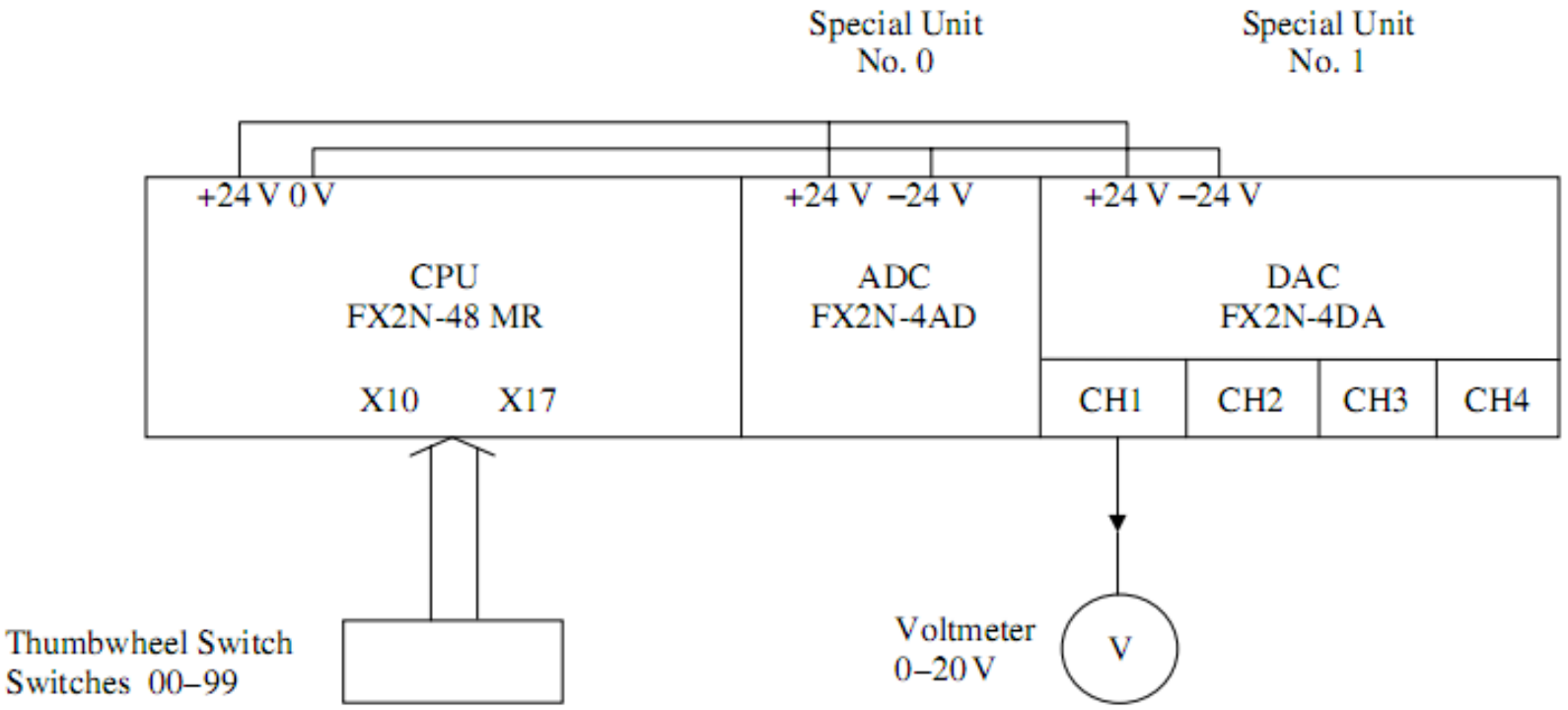
Data value 0: Pre-set range (−10 V to +10 V).
Data value 1: Pre-set range (+4 mA to +20 mA).
Data value 2: Pre-set range (0 mA to +20 mA).




Therefore, when H2110 is entered into buffer memory 0 then:

1. Channel 1 is set for −10 V to +10 V.
2. Channel 2 is set for +4 mA to +20 mA.
3. Channel 3 is set for +4 mA to +20 mA.
4. Channel 4 is set for +0 mA to +20 mA.

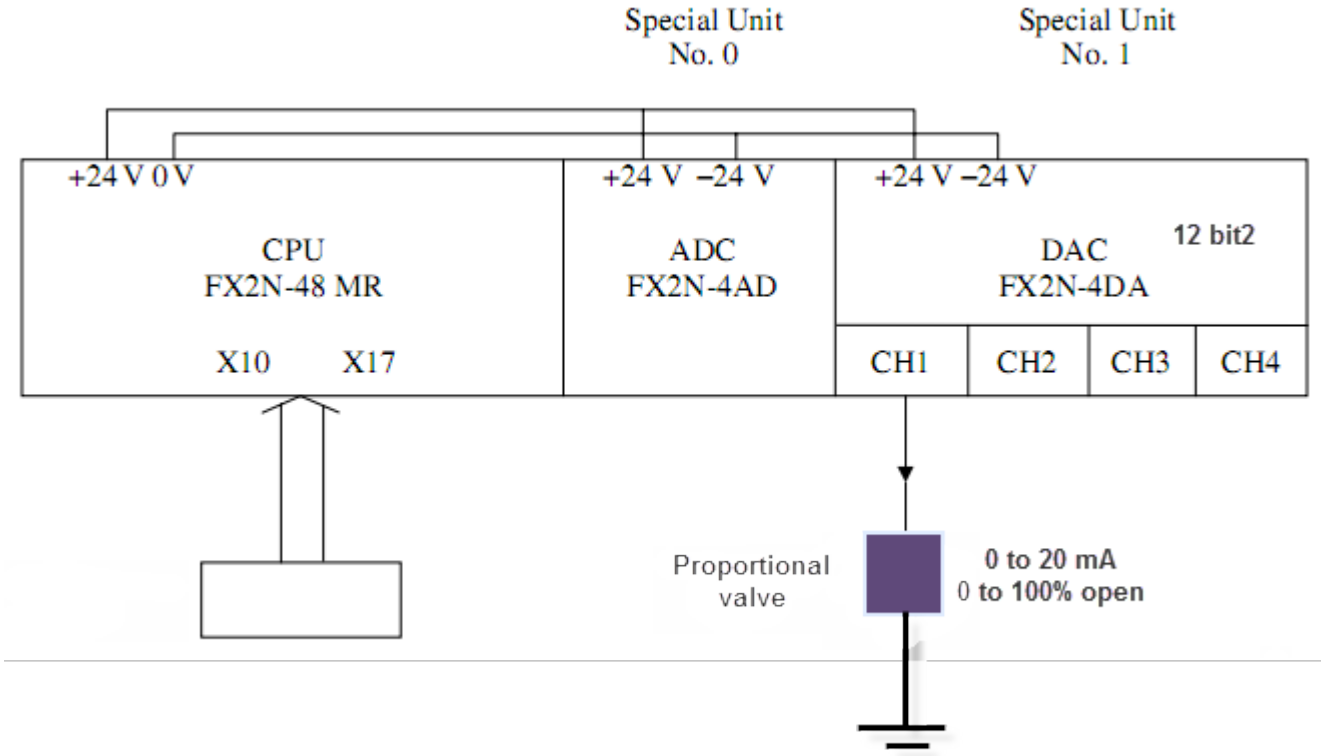
# Position and Wiring




TO K1 K0 H2110 K1

# Quiz

- Given




**1/ Define H value.**
**2/ Write TO function to configure new H value to analog output module.**
**3/ Write TO function to write controlled value which stored in D100 to analog output module.**