Chapter (4)

Automation Summary
By Nada Ababneh

Automation → Automatic control

* Basic elements of an automated system
  → Power to acomplish the process and operate the automated system
  → Program of instructions to direct the process
  → Control system to actuale the instructions

① electricity (The principle power source)

Power to acomplish the automated process
→ Power for the process
→ power for the automation

② Program of instructions

: set of comands that specify the sequence of steps in the work cycle and details of each step
during each step there are one or more activities involving changes in one or more process parameters

example CNC Part Program

examples :- Temperature setting of a furnace
Axis position in a positioning system
Motor (on or off)

③ Control Systems

→ Closed loop control system (Feedback) such as positioning system using feedback control
→ Open loop control system
  - actions performed are simple
  - actuating function is very reliable
  - reaction forces are small

* Examples of Automation :

Day to Day life
- ATM
- vending Machines
- Starting of the vehicle
- Car wipers

Industry
- Painting Robots in the Automobile
- Soldering Machines
- Automatic Capping Machines
- Automatic Filling Machines
- car painting
- cars manufacturing
- soldering and brazing machines
- bottle Filling and capping
- Packaging

Home Automation
- Hot water systems
- Lightning
- Air Conditioning
- Powerd window blinds
- Garage Doors
- Security Systems

* Advanced Automation Functions

→ not specific to a particular work unit
[enhancing the safety and performance of the equipment]

→ Safety monitoring
→ Maintenance and Repair diagnostics
→ Error detection and recovery

* Why Automation is Required ?

→ increase in comfort
→ more safety
→ improve the quality and precision
→ to do the Job for which human beings will not have the capacity
→ to avoid monotonous work

* Manufacturing Systems :-

can be defined as a collection of integrated equipment and human resources that performs one or more processing and assembley opperations on a starting work material part or set of parts

(accomplish the value added work on the part or product)

→ the integrated equipment consists of :-
* production machines
* material handling
* positioning devices
* computer systems

Manufacturing Systems

Automation Hierarchy

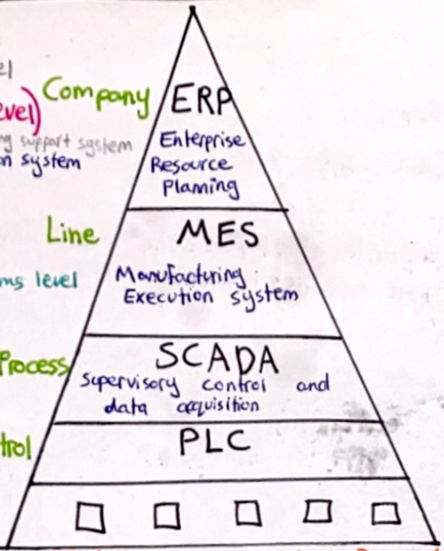
Management level
(Enterprise level) Company
manufacturing support system
Corporate information system

(Plant level) Line
Factory of production systems level

(Cell or system level) Process

(Machine level) control

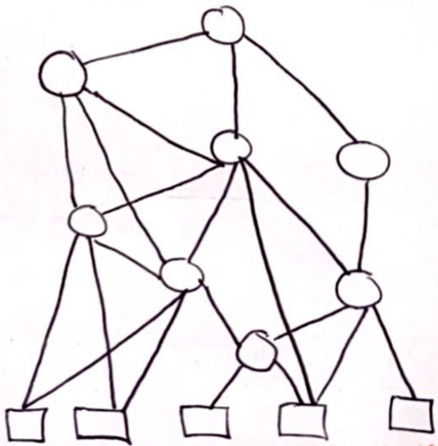
(Device level) Field
actuators, sensors, other hardware components



Traditional Automation Pyramid
Traditional manufacturing system

Breaking Hierachies

CPS
Cyber Physical Systems



Device to Device Communication
Smart manufacturing system

*Levels of Automation

Chapter (6)

output of an controller is always digital

Hardware Components for Automation and Process Control

- Sensors
- Actuators
- Analog to Digital Conversion
- Digital to Analog Conversion

على الأغلب نتكلم عن closed loop وبالعادة بيستخدم digital controller

*What is a Process Control? → is the deploying of industrial control systems and control theory to monitor and adjust an industrial process to give a disered output

it is used in industry to
- maintain quality
- improve performance

example:

Temperature closed loop process control

- sensing element → thermometer
- measured parameter → Temperature
- Actuator → valve

* Process Control
  - → Analog Controller [Analog signal → the signal that changes its sign in a period of time
    - 3 types
      - sine-wave
      - squared
      - triangle
  - → Digital Controller [Digital signal → the signal that doesn't change its sign]
    - 2 type
      - Binary pulses
        - either zero or one
      - Not Binary pulses

$\frac{E}{2}$ > → logic 1

$\frac{E}{2}$ < → logic 0

*Computer Process interface: to implement the process control, the computer must ① collect data and ② transmit signals to the production process

Computer ← collect data ← Production Process

Computer → transmit signals → Production Process

Application dependent device

→ convert natural phenomena into physical quantity

محول

*Sensors: is a transducer that converts a physical stimulus from one form into a more useful form to measure the stimulus

*Sensor Categories by stimulus → 1 Mechanical, 2 Electrical, 3 Thermal, 4 Radiation, 5 Magnetic, 6 Chemical

Sensors two basic categories

- Analog (continuous)
  - ✓ - Thermocouple
  - ✓ - Strain gauges
  - - potentiometers
  - ✓ - RTD
- (Discrete)
  - Binary (on/off)
    - ✓ - Limit switch
    - - photo electric switches
  - Digital (Pul...
    - ✓ - photo electric array
    - ✓ - optical encoder

Scanned with CamScanner

* Responsiveness is affected by
→ how accurate is the linearity
→ Temperature Range
→ Accuracy

* Analog Sensors (Continuous)

* **Thermocouple**: analog temperature measuring device based on themoelectric effect

* **Resistance temperature detector**: analog temperature measuring device based on increase in electrical Resistance of a metalic material as temperature increases

$R\uparrow \quad T\uparrow$

$R = \frac{\rho L}{A}$

RTD → metal → Linear Relationship
Thermistor → semi conductor → inverse Relationship

* **Strain gauges**: widely used analog sensor to measure
  - Force
  - Torque
  - Pressure

Tension $A\downarrow \dots R\uparrow$

Compression $A\uparrow \dots R\downarrow$

Digital Sensors (Discrete)

* **Limit switch**: [mechanical] Binary contact sensor in which lever arm or push button closes or opens an electrical contact.

Sensor output: voltage signals or change in signals (electrical signals)

* **Optical Encoder**: Digital device used to measure position and speed consisting of a slotted disk separating a Light source from a photo cell.

gives indication on revolution per minute

* **photoelectric sensory array**: Digital sensor consisting of Linear series of photoelectric switches. Array is designed to indicate height or size of objects.

* Input/Output Relation of Sensors

$$S = f(s)$$

S: output signal; f: functional relationship; s: stimulus

for binary sensors
$S = 1$ for $s > 0$ (+)
$S = 0$ for $s \leq 0$ (−)

for analog →

$$S = C + ms$$

S: output signal
C: output value at a stimulus value of zero
s: stimulus
m: constant of proportionality (sensitivity) slope, determines the relation between S and s

Chapter (6)

Input/output relation of sensors

$$\boxed{S = f(s)}$$

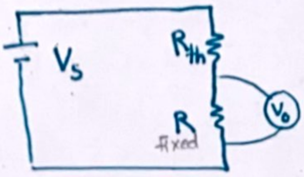
for binary sensors

$S = 1$ if $s > 0$ (+)

$S = 0$ if $s \leq 0$ (−)

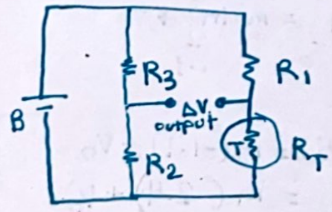
$$\boxed{S = C + ms}$$

Sensor Signal Conditioning Circuits



$$V_o = V_S \times \frac{R}{R + R_{th}}$$

Temperature Measuring Voltage Divider



$$\Delta V = E\left(\frac{R_2}{R_2 + R_3} - \frac{R_T}{R_T + R_1}\right)$$

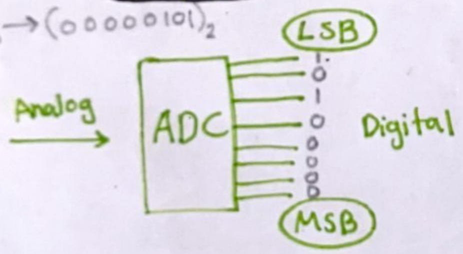
Temperature Measuring Wheatstone Bridge

Stepper Motors

$$\boxed{\alpha = \frac{360}{n_s}} \quad \boxed{A_m = n_p \alpha} \quad \boxed{\omega = \frac{2\pi f_p}{n_s}} \quad \boxed{N = \frac{60 f_p}{n_s}}$$

ATD

$(5)_{10} \rightarrow (00000101)_2$



sample rate $f_s = \frac{1}{T}$

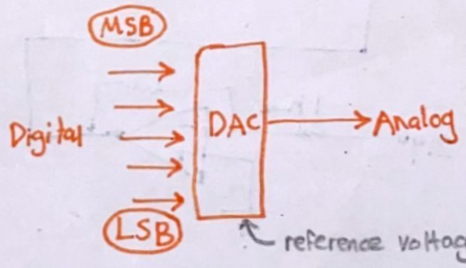
* for successive Approximation method

$V_{input} > V_{Trial} \longrightarrow$ Digital output $= 1$

$V_{input} < V_{Trial} \longrightarrow$ Digital Output $= 0$

(weight) Encoded value of the input signal $= \sum \begin{pmatrix}\text{Digital}\\\text{output}\end{pmatrix} \times \begin{pmatrix}\text{Trial}\\\text{Voltage}\end{pmatrix}$

DTA



\# of bits

$$\boxed{V_{out} = V_R\left(b_1 2^{-1} + b_2 2^{-2} + \dots + b_n 2^{-n}\right)}$$

example digital word 4 bits

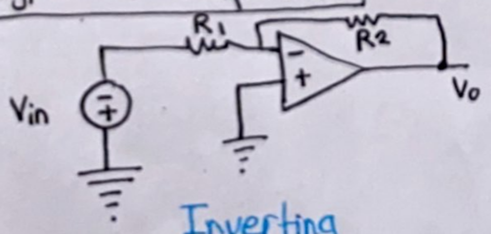
$V_{max} = V_R(2^{-1} + 2^{-2} + 2^{-3} + 2^{-4})$

$= 0.9375\, V_R$

$$\boxed{V_{out} = \frac{N}{2^n} V_{ref}}$$

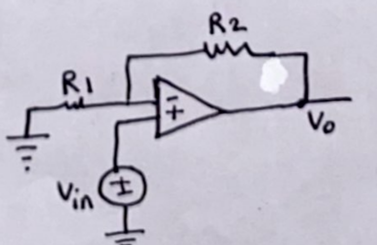
N = in decimal

Types of Amplifiers



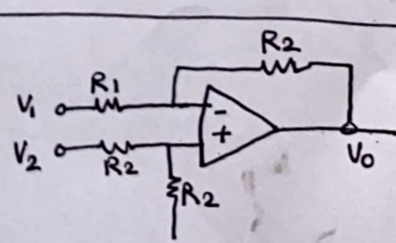
Inverting

$$TF = \frac{V_o}{V_i} = \frac{-R_2}{R_1}$$



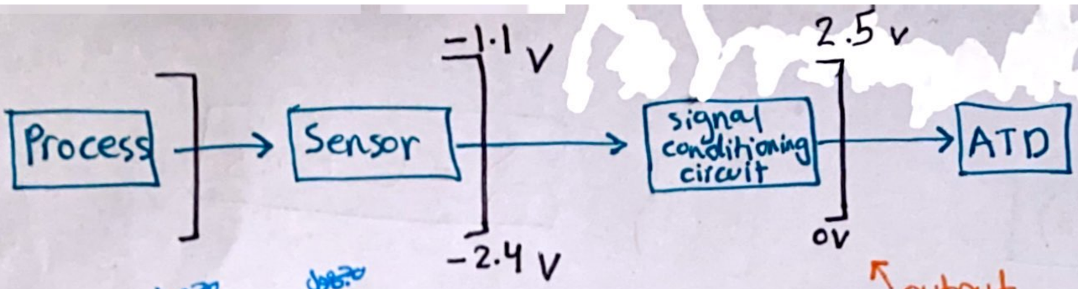
Non-Inverting

$$T_F = \frac{V_o}{V_{in}} = 1 + \frac{R_2}{R_1}$$



Defferential

$$TF = \frac{V_o}{V_{in}} = \frac{R_2}{R_1}(V_2 - V_1)$$



$V_{out} = mV_{in} + V_o$

$V_{out}\Big]_{0}^{2.5V} = mV_{in}\Big]_{-2.4V}^{-1.1V} + V_o$

$$\left.\begin{aligned} 2.5 &= m(-1.1) + V_o \\ 0 &= m(-2.4) + V_o \end{aligned}\right] \rightarrow \text{on calculator}$$

$V_o = 2.4m$

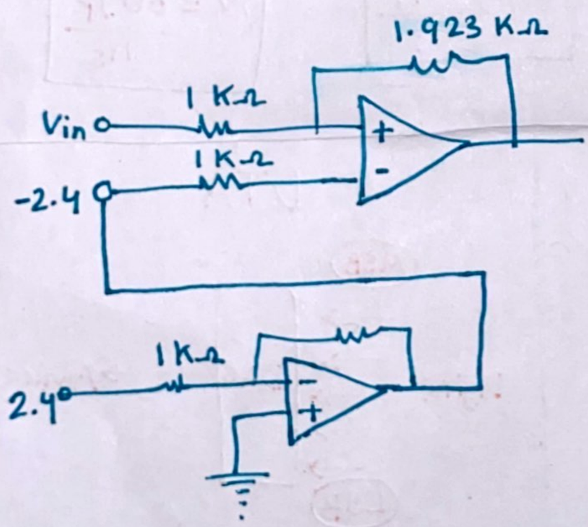
$m = 1.923$

$V_o = 4.615$

Differential Amplifier

$$\boxed{\overset{S}{V_o} = \overset{m}{1.923}\,\overset{s}{V_{in}} + \overset{C}{4.615}} \longrightarrow V_o = 1.923(V_{in} + 2.4) = 1.923(V_{in} - (-2.4))$$

$$TF = \frac{V_o}{V_{in}} = \frac{R_2}{R_1}(V_2 - V_1)$$



Discrete Control Using Programmable Logic Controllers

→ Discrete Process Control
→ Ladder Logic Diagram
→ Programmable Logic Controllers (PLC)

Chapter (9)

Sensors	Actuators
- limit switch	- Motor
- photo detector	- Valve
- timer	- clutch
- push button switch	- control relay
- control relay	- Light
- circuit breaker	- solenoid

Digital Variables → 1 (high), 0 (Low)

(A) Level, (B) Pressure, (C) Temperature, (D) Alarm

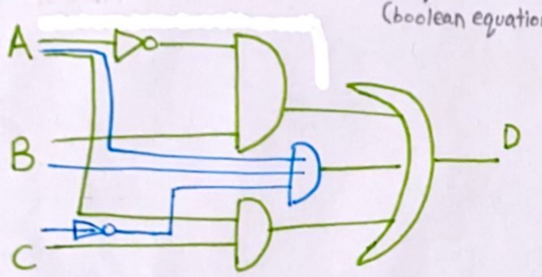
D = 1 when:

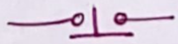
$D=\bar{A}.B$ * Low Level, High Pressure

$D=A.C$ * High Level, High Temperature

$D=A.B.\bar{C}$ * High Level, Low Temperature, High pressure

final Logic equation (boolean equation) → $\boxed{D=\bar{A}.B+A.C+A.B.\bar{C}}$

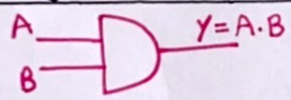
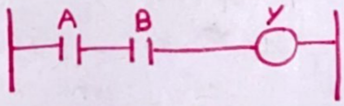
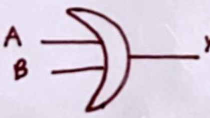
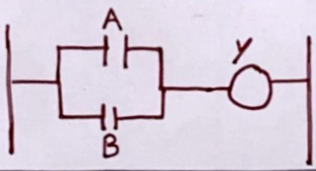
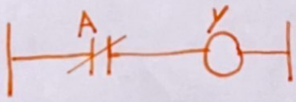
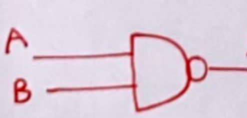
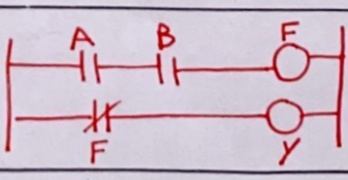
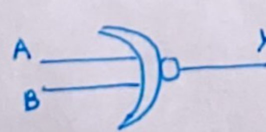
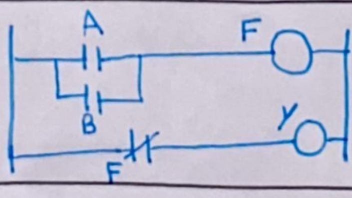
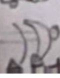




NC push button

ex
* pressure switch open → B=0
closed → B=1

Fundamentals of Logic

Gate Name	Logic Symbol	Ladder Logic program	NOTES
AND ($Y=A.B$)	 $Y=A.B$		لو أي input ←0 الـ output ←0 لو كلهم شغالين يعني كل الـinputs ←1 اذا الـoutput ←1
OR ($Y=A+B$)	 $Y=A+B$		لو أي input ←1 اذا output ←1
NOT $Y=\bar{A}$	 $Y=\bar{A}$		عكس الـ input $1 \Rightarrow 0$ $0 \Rightarrow 1$
NAND $Y=\overline{A.B}$	 $Y=\overline{A.B}$		اذا الـ 2 inputs ←1 ⇐ output= 0 inputs 0 0 → 1 1 0 → 1 0 1 → 1
NOR $Y=\overline{A+B}$	 $Y=\overline{A+B}$		inputs 0 0 ⟹ 1 (Y) A B → Y 0 1 → 0 1 0 → 0 1 1 → 0
XOR XNOR عكس  $\bar{A}\bar{B}+AB$	 Y		input متشابه → output zero input مختلف → output one

AND form	OR form
$1A = A$	$0 + A = A$
$0A = 0$	$1 + A = 1$
$AA = A$	$A + A = A$
$A\bar{A} = 0$	$A + \bar{A} = 1$
$A.B = B.A$	$A + B = B + A$
$(AB)C = A(BC)$	$(A+B)+C = A+(B+C)$
$A + (B.C) =$ $(A+B).(A+C)$	$A(B+C) = AB + AC$
$A(A+B) = A$	$A + AB = A + B$
	$\bar{A} + AB = \bar{A} + B$
$\overline{A.B} = \bar{A} + \bar{B}$	$\overline{A+B} = \bar{A}.\bar{B}$

$\bar{A}B + A\bar{B} = A + B$

$(($أي اشي$) + 1) = 1$

(PLC)

An Industrial Robot

part

human worker

X_1 (NO normally open)

nest used to indicate that the part is in the nest

Y_1

Robot

picks up the part

place the part here

X_2 indicate the part is placed into the induction heating coil

induction heating coil

C_1

T_1 10 sec

for heating operation

X_1 energizes Y_1 to signal the robot to do step 2

Y_2

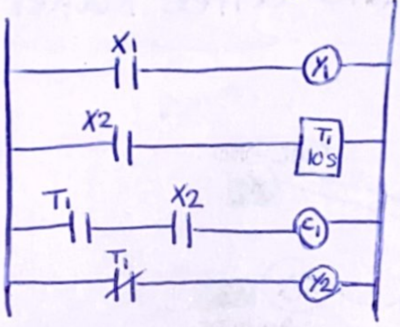
Robot

to signal the robot to execute step 4

reaches coil and take the part

place it on an outgoing conveyer

Ladder Diagram



inputs → X_1, $X2$

Timers → T_1

Outputs → Y_1 robot signal nest to heating coil, C_1 heating coil, $Y2$ robot signal

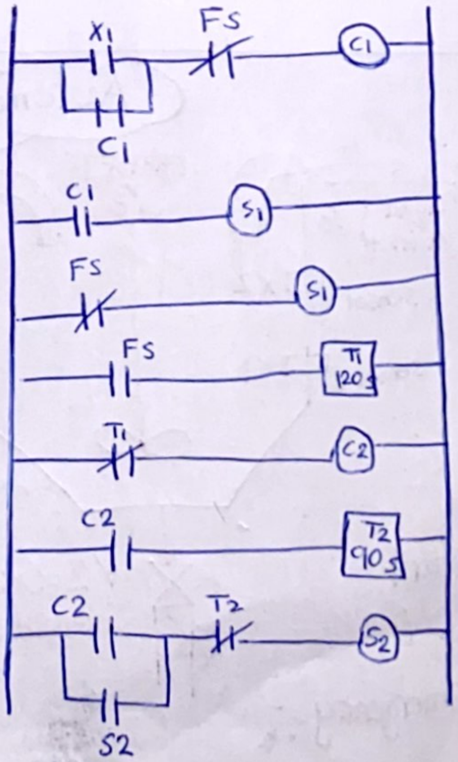
Fluid storage Tank

$X_1 \longrightarrow C1 \longrightarrow S_1$ valve

FS

$FS \longrightarrow T_1$ 120s $\longrightarrow C2 \longrightarrow T_2$ 90s, S_2 valve

Ladder Diagram



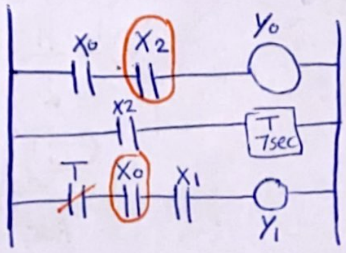
احيانا" حل ال PLC ممكن يختلف

Automatic Closing Door (PLC)

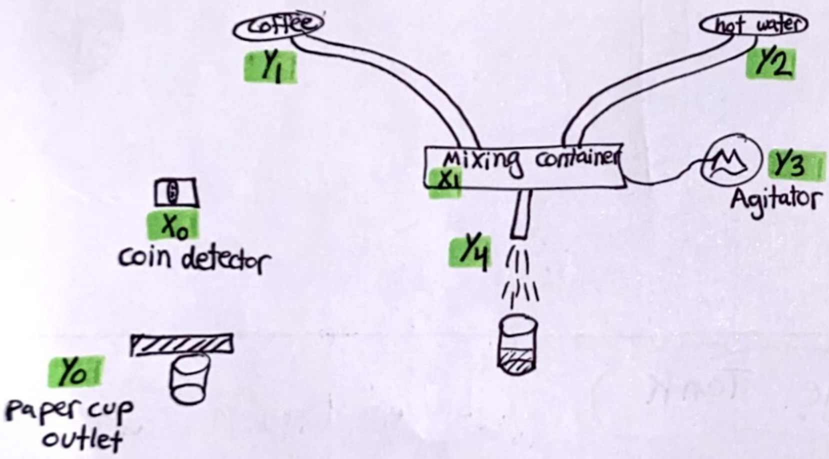
inputs
- X_0 (infrared sensor)
- X_1 (close limit switch)
- $X2$ (open limit switch)

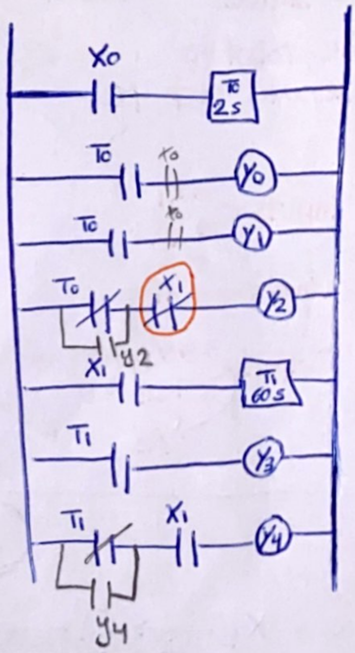
time → T (7 seconds)

outputs
- Y_0 (open the door)
- Y_1 (close the door)

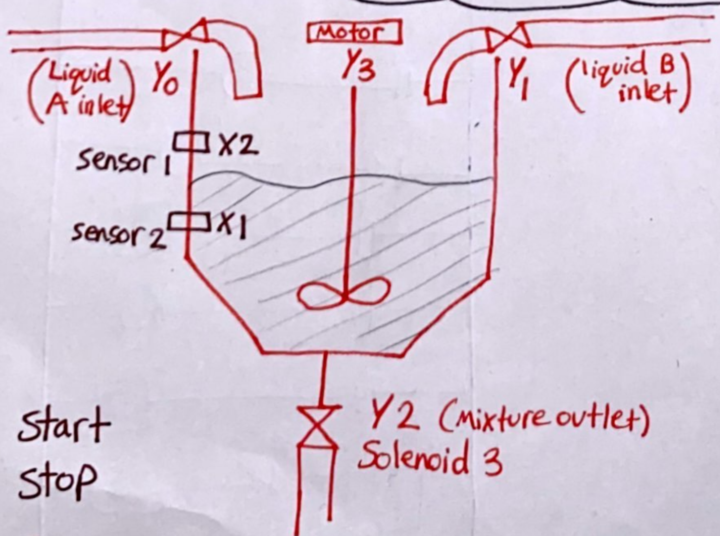


Automatic Coffee Maker





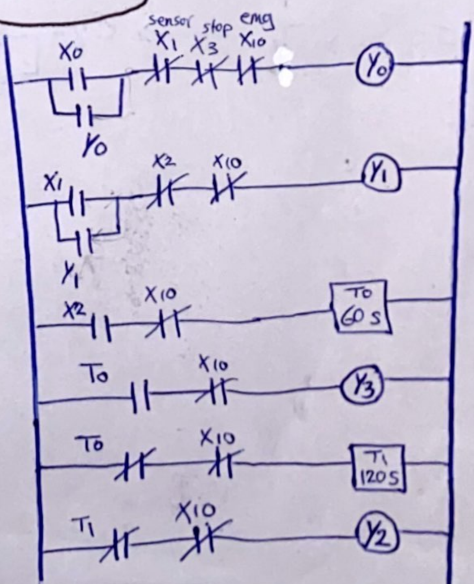
Automatic Infusing Container



X_0 Start

X_3 Stop

X_{10} Emergency



Product volume $\uparrow \left(\frac{1}{\alpha}\right)$ product variety $\downarrow$

علاقة عكسية

Single Station Manufacturing

↑ flexibility

→ Manned Machine

→ Automated Machine

الموضوع يعتمد على الموازنة بين عدد ال workers و ال machines

Chapter (14)

* single station Manufacturing cells
  - → the most common
  - → operation is independent
  - → performs operations → processing or assembly

* Single Station Manned cell — one worker tending one production machine
  - → mostly used in → Job shop / batch production
  - [Resons for popularity]
    - → shortest time to implement
    - → requires least capital investment
    - → easiest to install and operate
    - → the lowest unit cost for low production
    - → most flexible for product and change over

* parts storage subsystem and automatic parts Transfer

$$\boxed{UT = n_p T_c}$$

- UT → unattended time of operation
- n_p → # of parts in the storage subsystem
- T_c → cycle time (T_c is equall for all parts)

* parts storage capacity

make $n_p T_c =$
- → a fixed time interval that allows one worker to tend multiple machines
- → time between scheduled tool changes
- → one complete shift
- → one overnight

* storage Capacity of one part

with pallet changer →
$$\boxed{T_c = T_m + T_s}$$

- T_m → machine time
- T_s → worker service time

with no pallet changer →
$$\boxed{T_c = Max\{T_m, T_s\} + T_r}$$

- T_r → repositioning time of pallet changer production line

chapter (16)

Automated Production Lines

(Fixed Routing manufacturing system)

- → high production of parts
- → fixed operation

where to use

- → high product deman
- → Stable product design
- → long product life
- → Multiple operations required on product

***Applications**

- → Transfer lines
- → Robotic spot welding lines in automotive final assembly
- → Sheet metal stamping
- → Electroplating of metals
- → Rotary transfer machines

***Benefits**

- → Low direct labor content
- → Low production cost
- → high production rates
- → production lead time and wip are minimized
- → factory floor space is minimized

lead time:
is the period of time between merchant's (التاجر) purshace order being placed and the manufacturer completing the order

***system configuration**

- → In-Line
- → segmented In-Line
  - → L-shaped Layout
  - → U-shaped Layout
  - → Rectangular configuration
- → Rotary indexing machine
  - → (example: dial indexing macnine)

***work part tranfer**

- → palletized transfer line
- → Free Transfer line

***Work part Transfer Mechanisms**

- → Linear transfer systems
  - → Continuous → not common
  - → Synchronous → parts moves simult
  - → Asynchronous → parts move independently
- → Rotary indexing mechanisms
  - → Geneva mechanism
  - → other

- Belt Driven Linear Transfer system
- Walking beam Transfer system (↑, ↓, →)
- Geneva mechanism with six slots
- Cam mechanism to Drive dial indexing table
- Storage buffer
- Standard feed units (→ horizontal, → angular, → vertical) feed drive unit
- Rotary Transfer machine (4 horizontal spindle)
- center column machine (→ 2 angular, → 4 vertical, → 4 horizontal spindles)

***Control Functions**

- → sequence control
- → safety monitoring
- → Quality control

***Analysis of transfer lines**

- → line balancing
- → processing technology
- → System Reliability

chapters 7
13
18
19
are not included in the summary :)