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*Booklets*

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# Title: Reconstruction of motor voltage control signal in industrial applications using IoT

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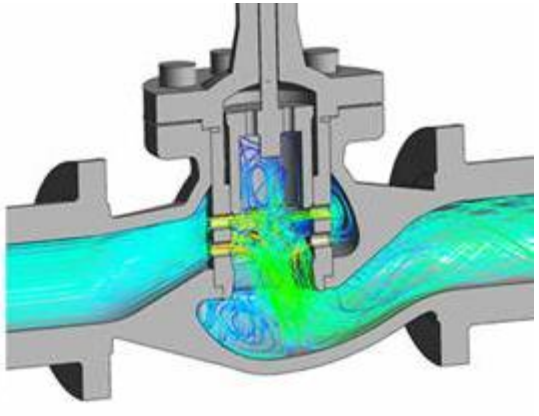
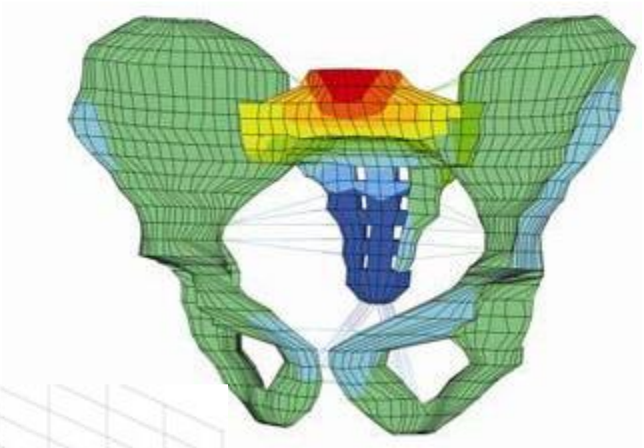
# PRESENTATION CONTENT

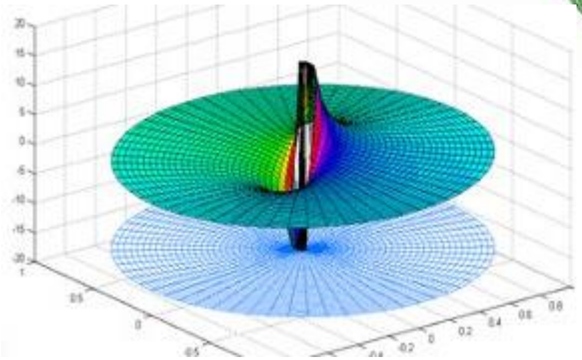
# Introduction

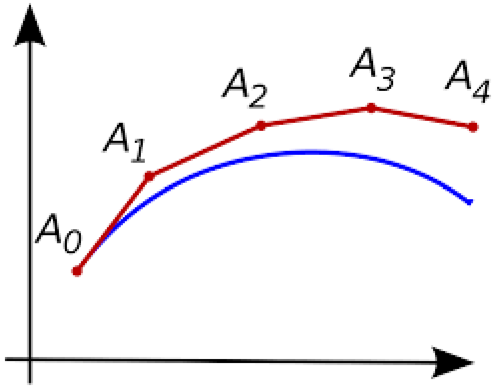
$$\begin{cases} f_1(x_1,\dots,x_n) = 0 \\ f_2(x_1,\dots,x_n) = 0 \\ \vdots \\ f_n(x_1,\dots,x_n) = 0 \end{cases} \Longrightarrow F(x_1,\dots,x_n)$$

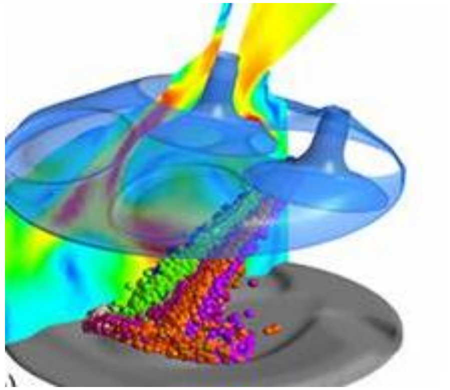
$$= (f_1,\dots,f_n)^T = 0$$







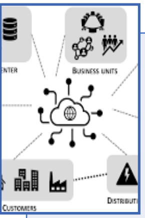


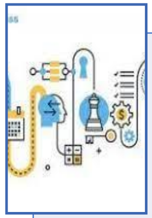



# Introduction


Manufacturing

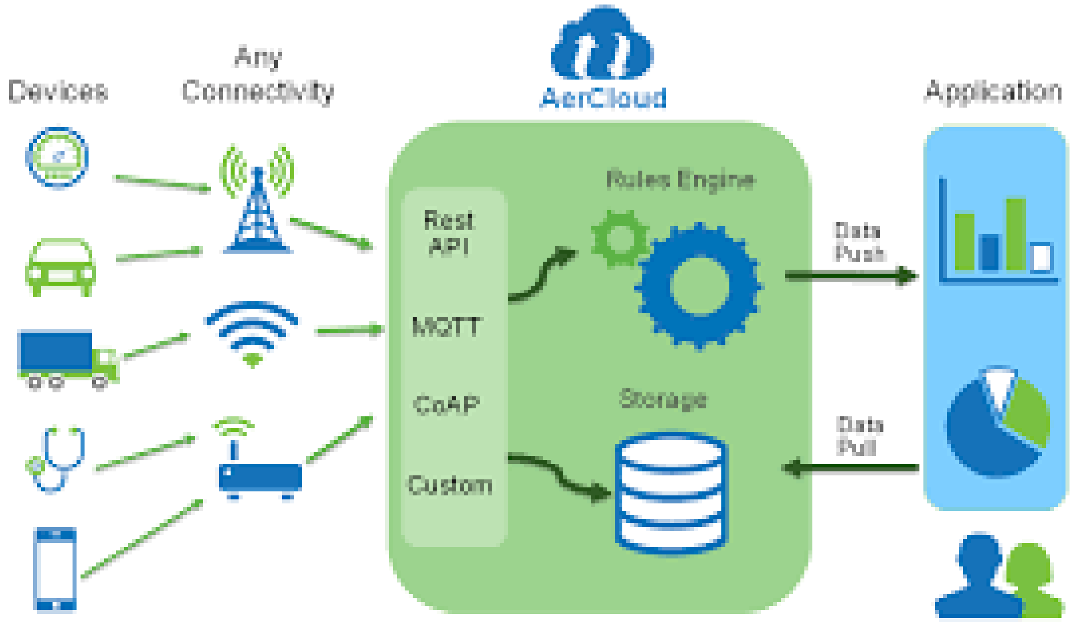

Vehicles


Smart grids

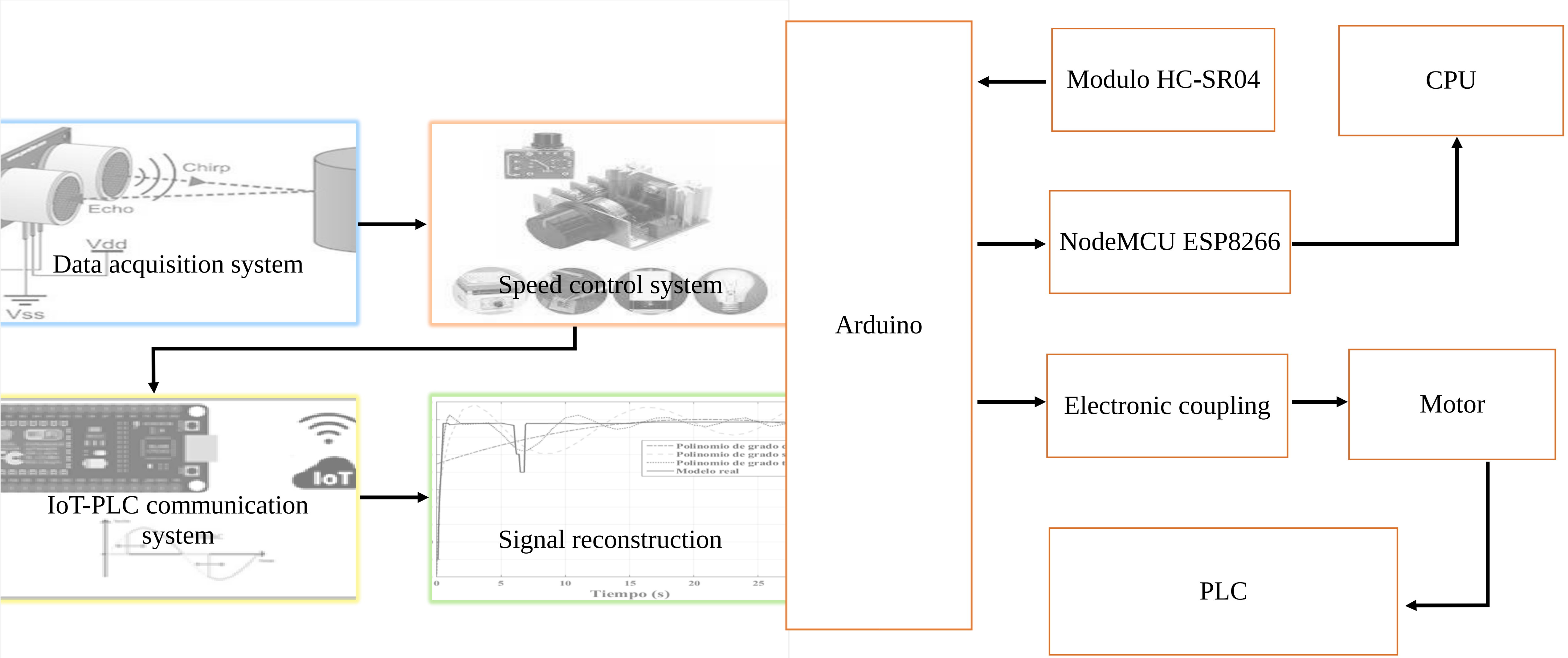

Optimization


Robots


Energy saving



# IIoT system proposed



# IIoT system proposed

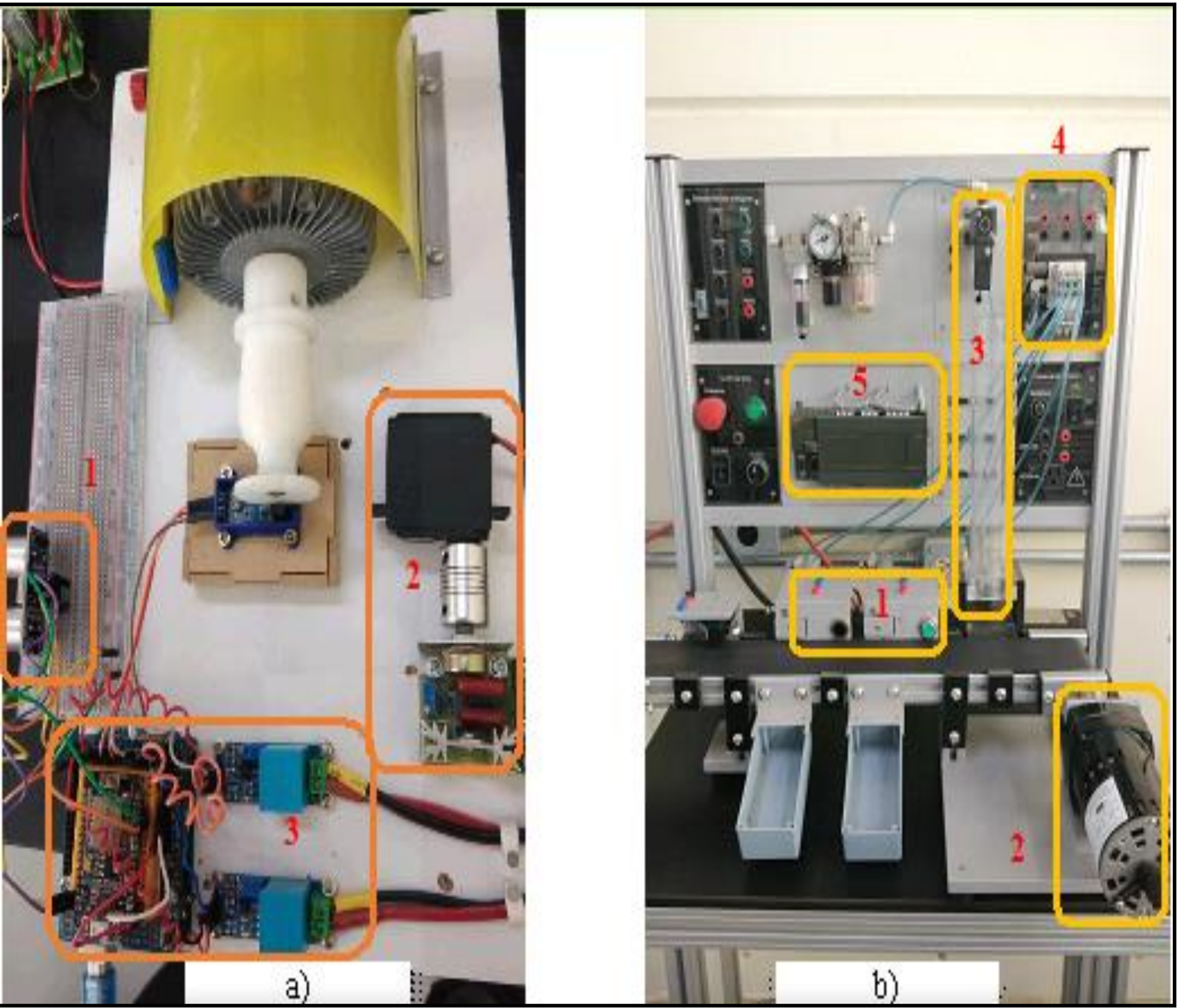
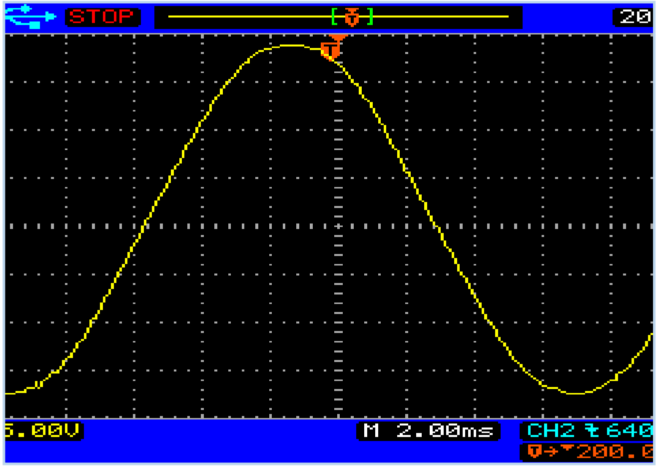



**Figure 5 (a) Electrical coupling of the IIoT system**
Data acquisition system (1)
Speed control system (2)
IIoT-PLC communication system (3)

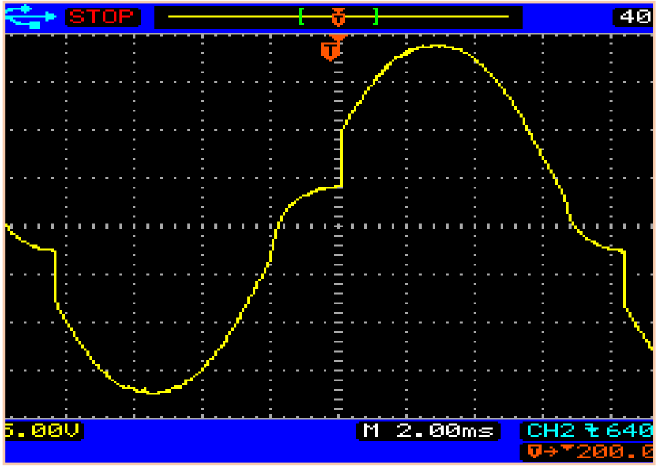
**Figure 5 (b) SIMATIC S7-200 PLC**
Pneumatic system for piston actuator (1)
Three-phase motor (2)
Material feed tower (3)
Solenoid valve system (4)
S7-200 CPU (5).

# Lab tests

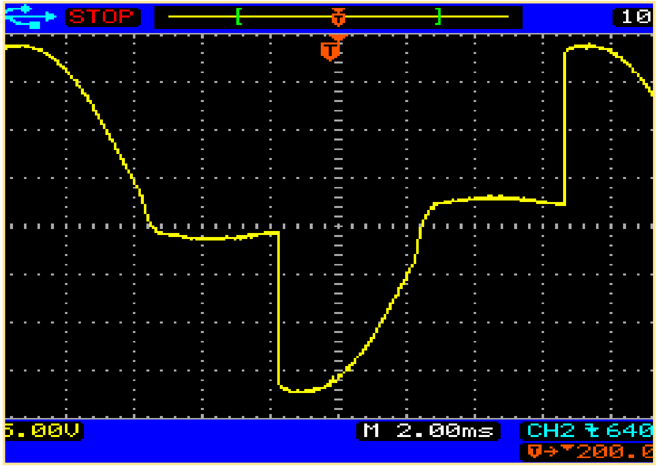
α=0°



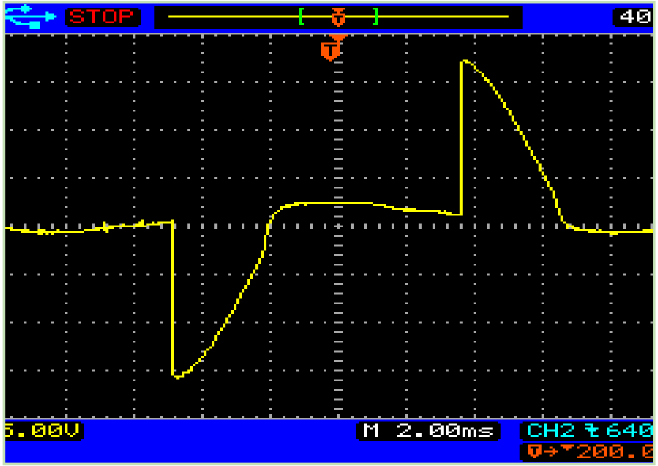

α=30°

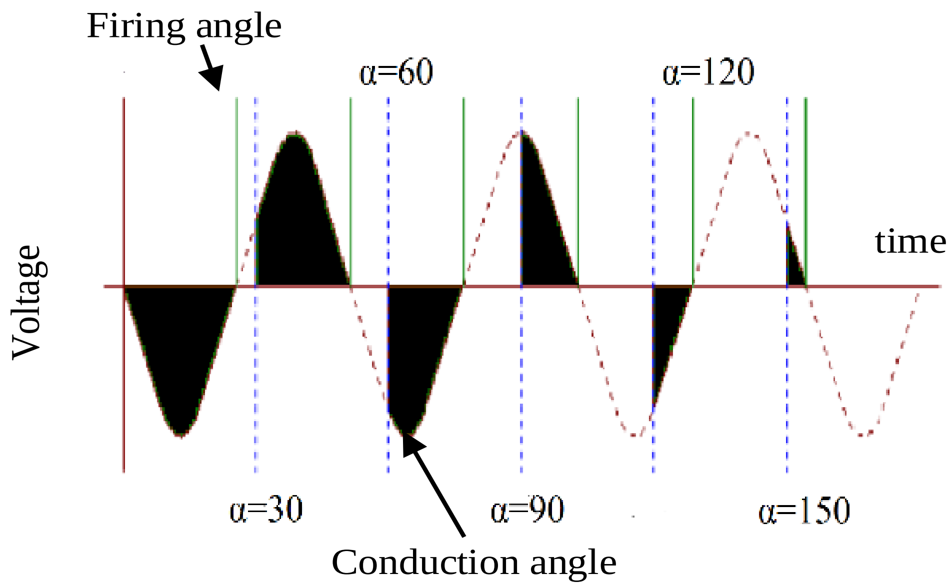



α=60°




α=90°



# Results

## Polynomial Approximation

$$y = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 + \cdots + a_n x^n$$

$$\downarrow$$

$$\boldsymbol{x}_1 = [\boldsymbol{n}_1, \boldsymbol{n}_2, \ldots, \boldsymbol{n}_k]$$

$$\boldsymbol{x}_2 = [\boldsymbol{n}_{k+1}, \boldsymbol{n}_{k+2}, \ldots, \boldsymbol{n}_p]$$

.

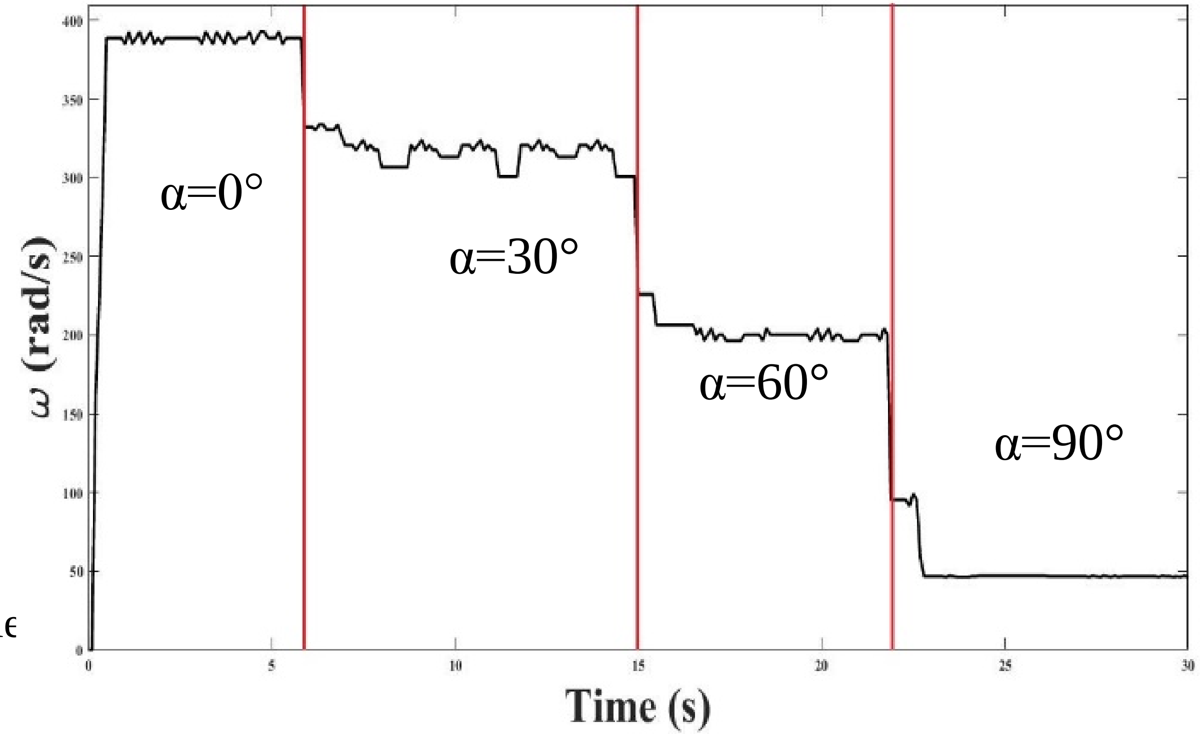
.

.

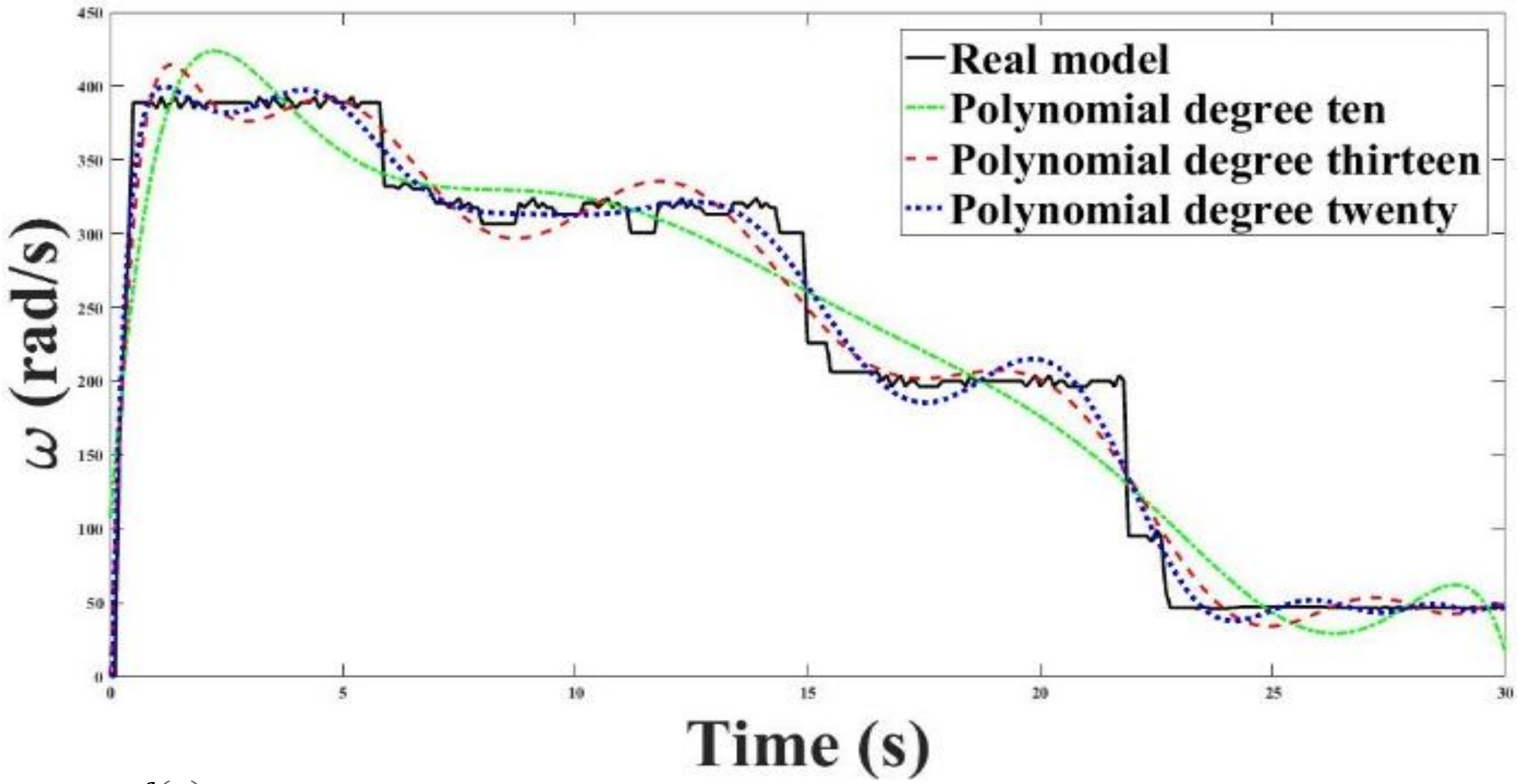
$$\boldsymbol{x}_l [=, \boldsymbol{n}_{q+1}, \boldsymbol{n}_{q+2}, \ldots, \boldsymbol{n}_m]$$

The relationship between the input and output variable corresponds to the firing angle ($\alpha$) and the angular velocity ($\omega$).

| Firing angle ($\alpha$) in degrees | Angular velocity ($\omega$) in RPM |
|---|---|
| **0°** | 3631.79 |
| **30°** | 3024.09 |
| **60°** | 1934.04 |
| **90°** | 492.81 |

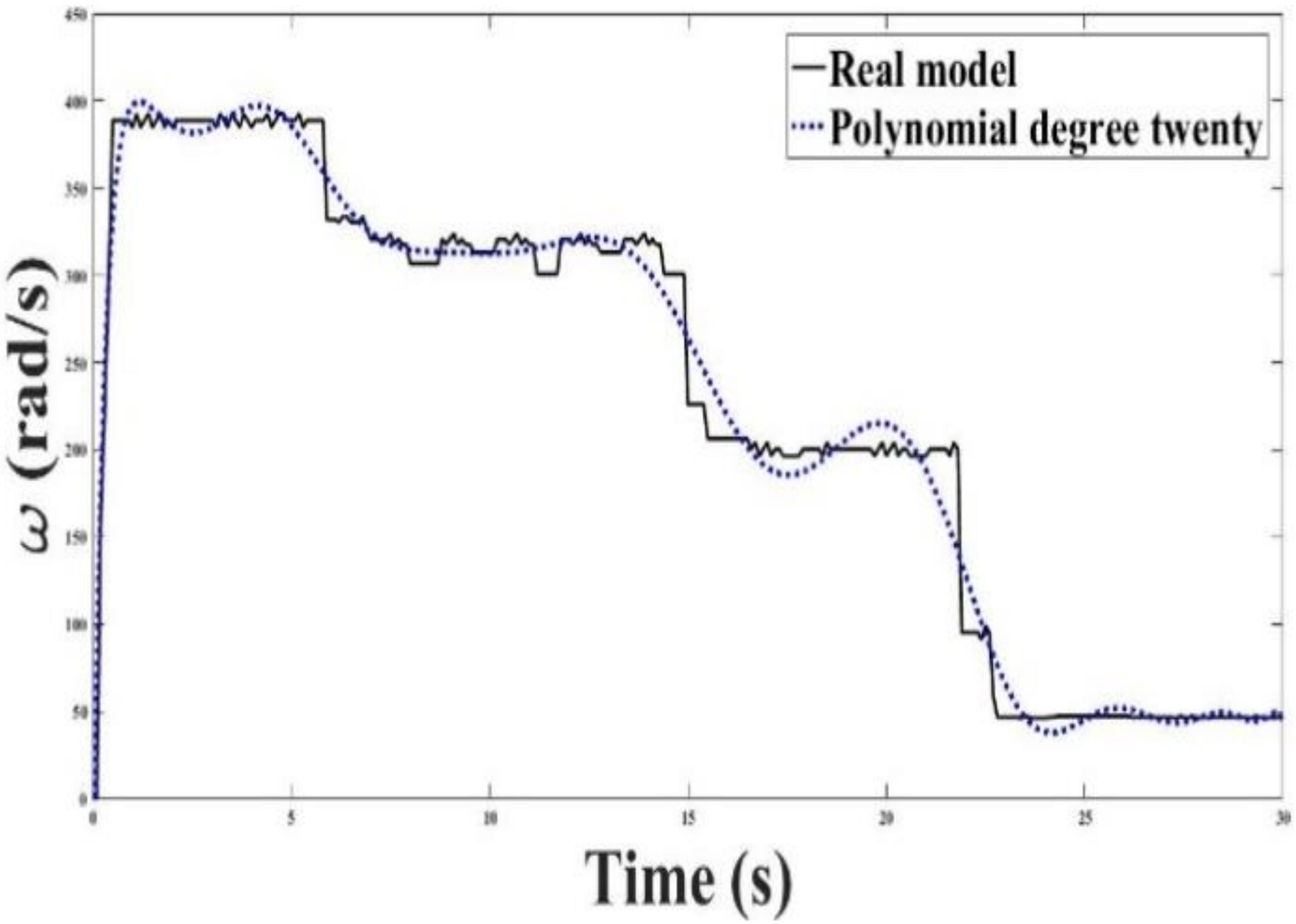


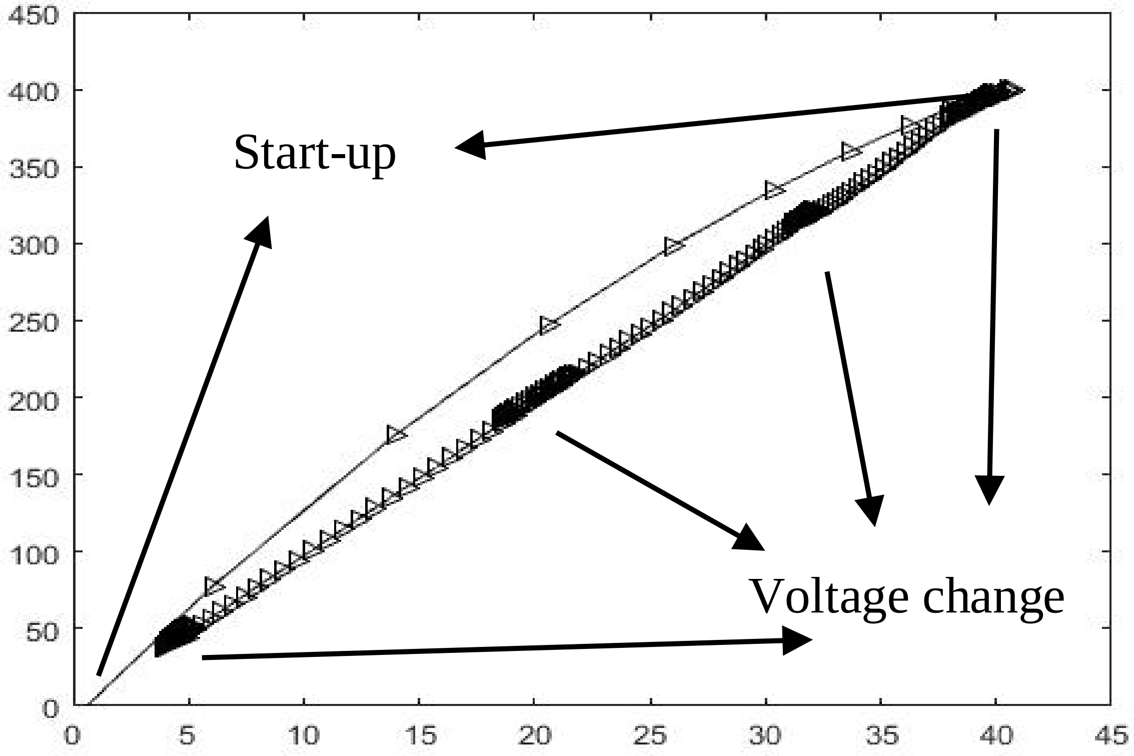
# Results




$$f(x) = -57.22 + 1555.34t - 2333.95t^2 + 2099t^3 - 1279.41t^4 + 554.04t^5 - 174.38t^6 + 40.63t^7 - 7.13t^8 + 0.96t^9 - 0.1t^{10} + \cdots - 3.18x10^{-18}t^{20}$$

# Results


Real model
Polynomial degree twenty
ω (rad/s)
Time (s)


Start-up
Voltage change

# Conclusions

The proposed system uses a single-phase motor, referring to the electrical coupling for control, the implementation allows to work properly with motors of similar characteristics, also meets the objective allowing to control the motor through the configuration provided by the algorithm and the control device interconnected to the IoT network.

Polynomials of different degrees are exposed in the work, in order to verify:

- The numerical method based on polynomial equivalents can approximate the physical model where the higher the degree of a polynomial the better approximation to the real model curve is obtained.

- If a better appreciation of the dynamics of the system is desired, it can be represented by sectioning the phenomenon in time windows for each voltage variation and obtain a polynomial approximation of lower degree.

Finally, future work will focus on working on the control of the three-phase motor, this will allow to keep the PLC module without costly and irreversible modifications.

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