

C213 – Sistemas Embarcados

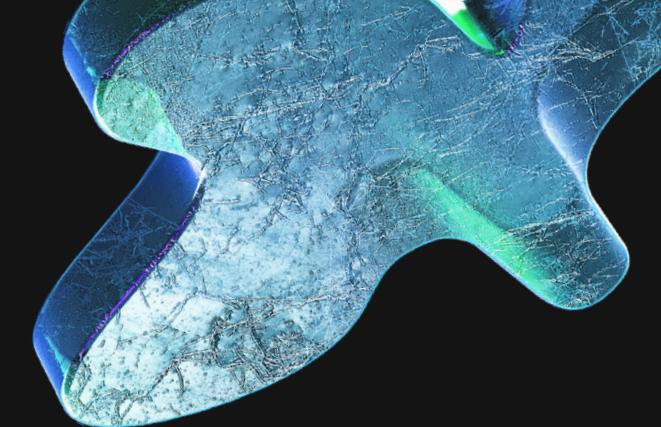
# Controladores Fuzzy

Fernanda Nagata Ito - 1759

João Henrique Silva Delfino - 1662

Paulo Otavio Luczensky de Souza - 1732

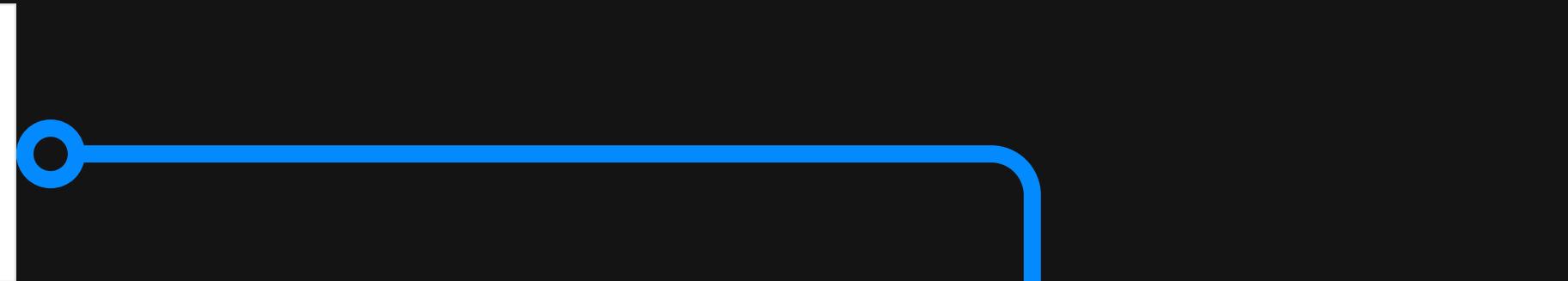
# Integrantes



## FerNagata - Overview

Computer Engineer . FerNagata has 12 repositories available. Follow their code on GitHub.

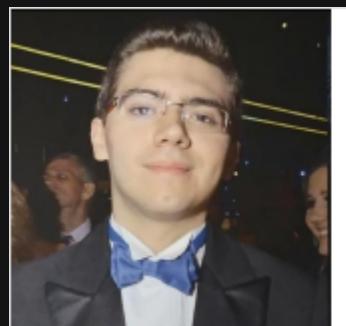
GitHub



## Joaohsd - Overview

Computer Engineering student at INATEL (2020.1). Coding readable and complete codes or trying to do that. - Joaohsd

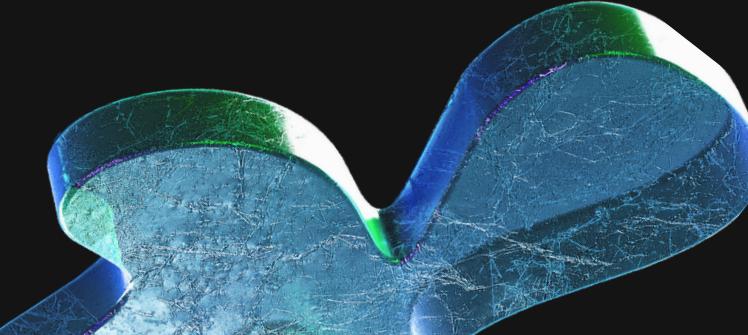
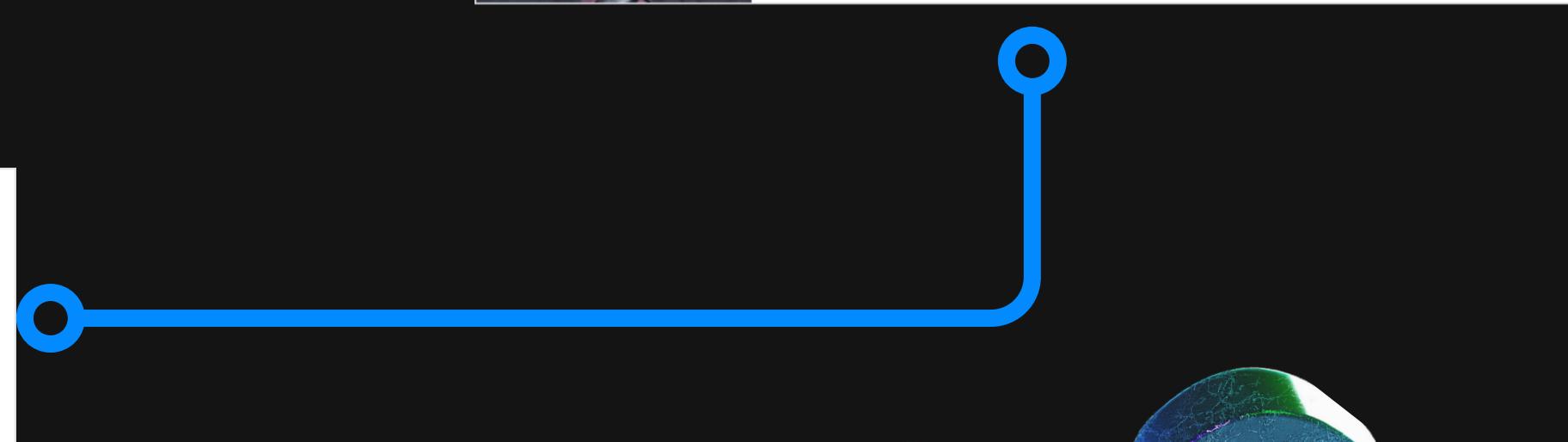
GitHub



## PauloLuczensky - Overview

PauloLuczensky has 14 repositories available. Follow their code on GitHub.

GitHub



# Introdução ao Projeto

A ideia do projeto é o controle de um sistema de refrigeração a partir da temperatura mensurada por um sensor e o uso da Lógica Fuzzy aplicada a tal.

# Descrição do Sistema

## Características do Sistema:

- Faixa de temperatura: -10 °C a 10 °C
  - Potência do Regrigerador: 0 a 100%
- 

## Modos de operação:

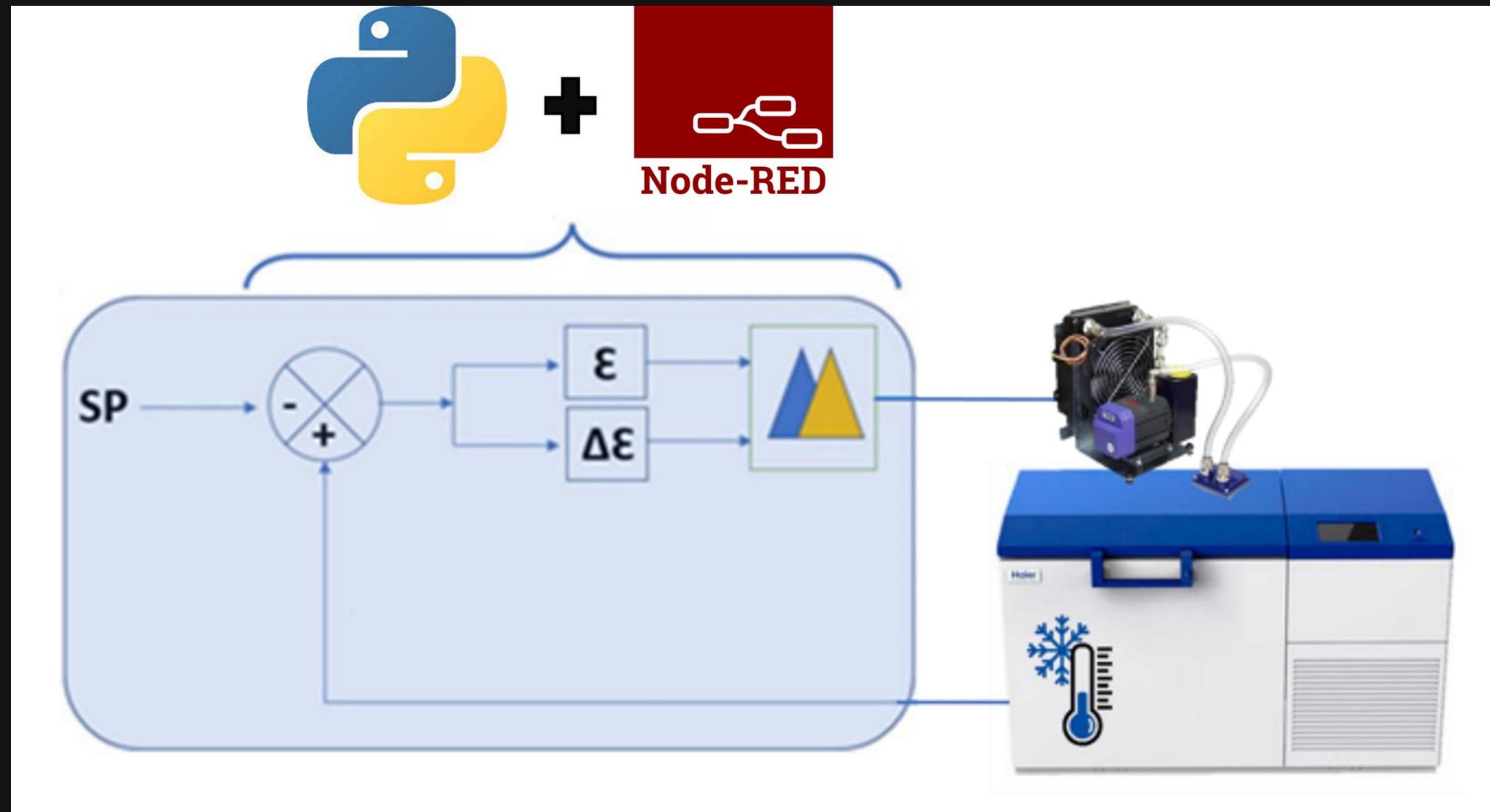
1. Armazenamento de Vacinas: -2 °C
  2. Temperatura de mantimento fora de operação: -6 °C
  3. Armazenamento de Amostras Biológicas: -8 °C
- 

## Função de Transferência do Sistema:

$$PV = 0.9952 * PV - 0.0003963 * \text{Potência}$$

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# Sistema em Malha Fechada



# Considerações de Projeto

Erro:

- Erro máximo (positivo):  $10 - (-8) = 18 \text{ } ^\circ\text{C}$
  - Erro máximo (negativo):  $-10 - (-2) = -8 \text{ } ^\circ\text{C}$
  - Tolerância de +/- 0,5 °C para o erro
- 

Variação do erro:

- Variação do erro máxima (positiva): 1 °C
  - Variação do erro máxima (negativa): -1 °C
  - Tolerância de +/- 0,1 °C na variação do erro
-

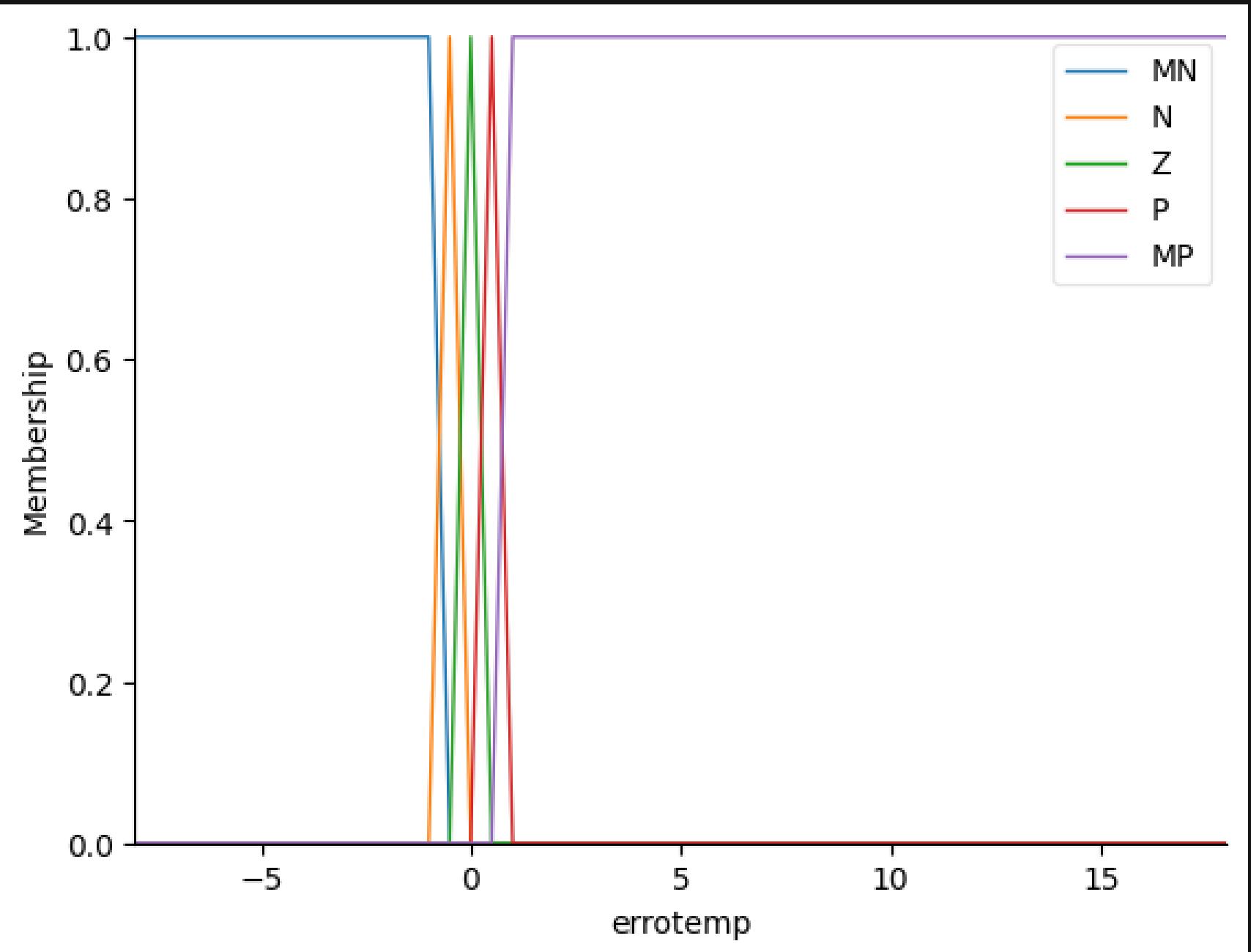
# Funções de Pertinência



# Erro

```
errotemp = ctrl.Antecedent(np.arange(-8, 18.1, 0.1), 'errotemp')

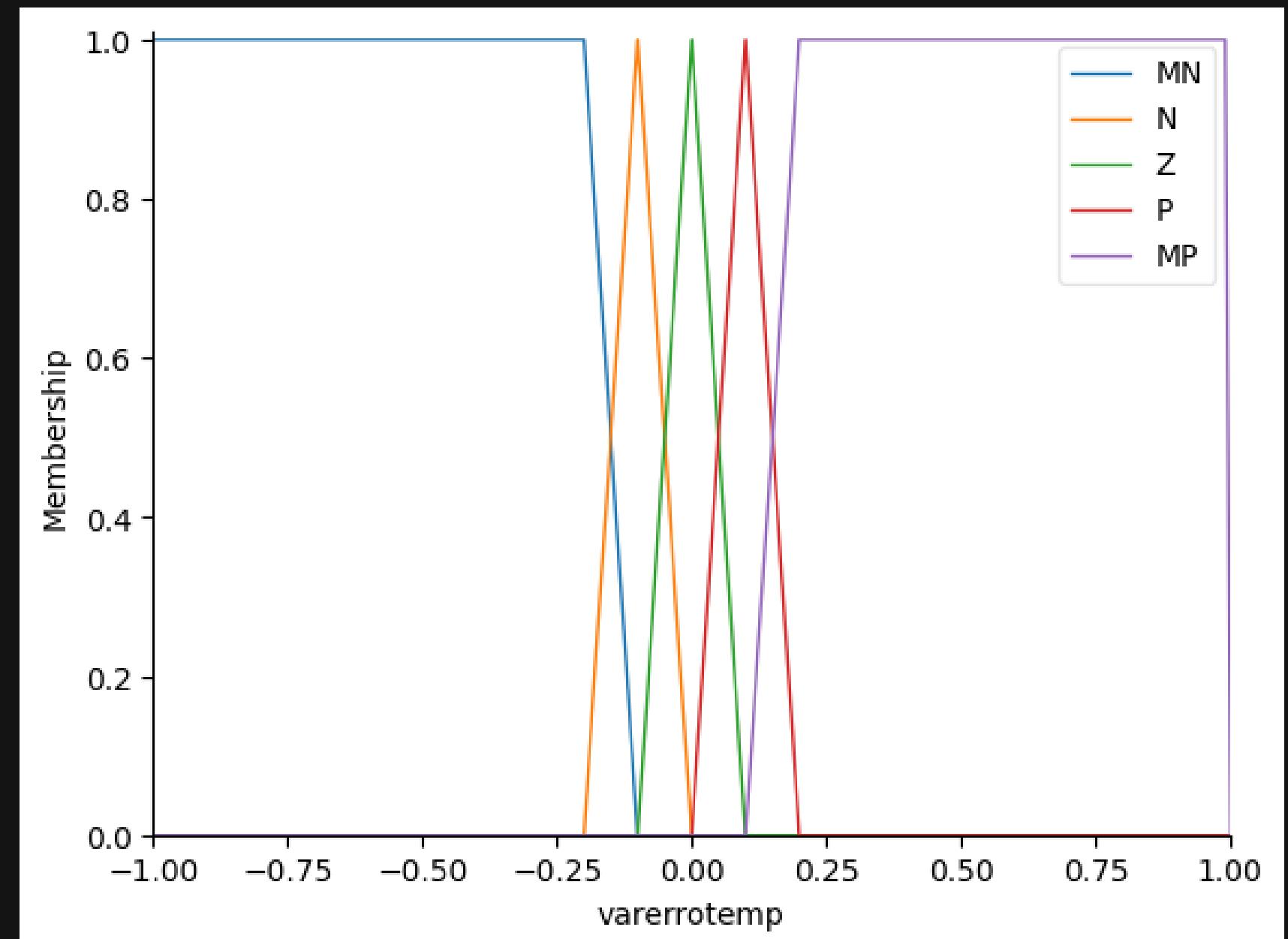
errotemp['MN'] = fuzz.trapmf(errotemp.universe, [-8, -8, -1, -0.5])
errotemp['N'] = fuzz.trimf(errotemp.universe, [-1, -0.5, 0])
errotemp['Z'] = fuzz.trimf(errotemp.universe, [-0.5, 0, 0.5])
errotemp['P'] = fuzz.trimf(errotemp.universe, [0, 0.5, 1])
errotemp['MP'] = fuzz.trapmf(errotemp.universe,[0.5, 1, 18, 18])
```



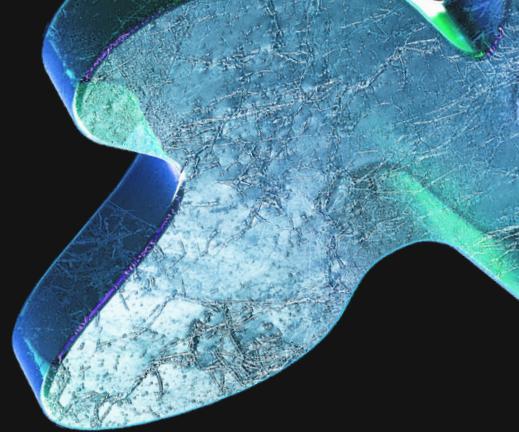
# Variação do Erro

```
varerrotemp = ctrl.Antecedent(np.arange(-1, 1.01, 0.01), 'varerrotemp')

varerrotemp['MN'] = fuzz.trapmf(varerrotemp.universe, [-1, -1, -0.2, -0.1])
varerrotemp['N'] = fuzz.trimf(varerrotemp.universe, [-0.2, -0.1, 0])
varerrotemp['Z'] = fuzz.trimf(varerrotemp.universe, [-0.1, 0, 0.1])
varerrotemp['P'] = fuzz.trimf(varerrotemp.universe, [0, 0.1, 0.2])
varerrotemp['MP'] = fuzz.trapmf(varerrotemp.universe,[0.1, 0.2, 1, 1])
```

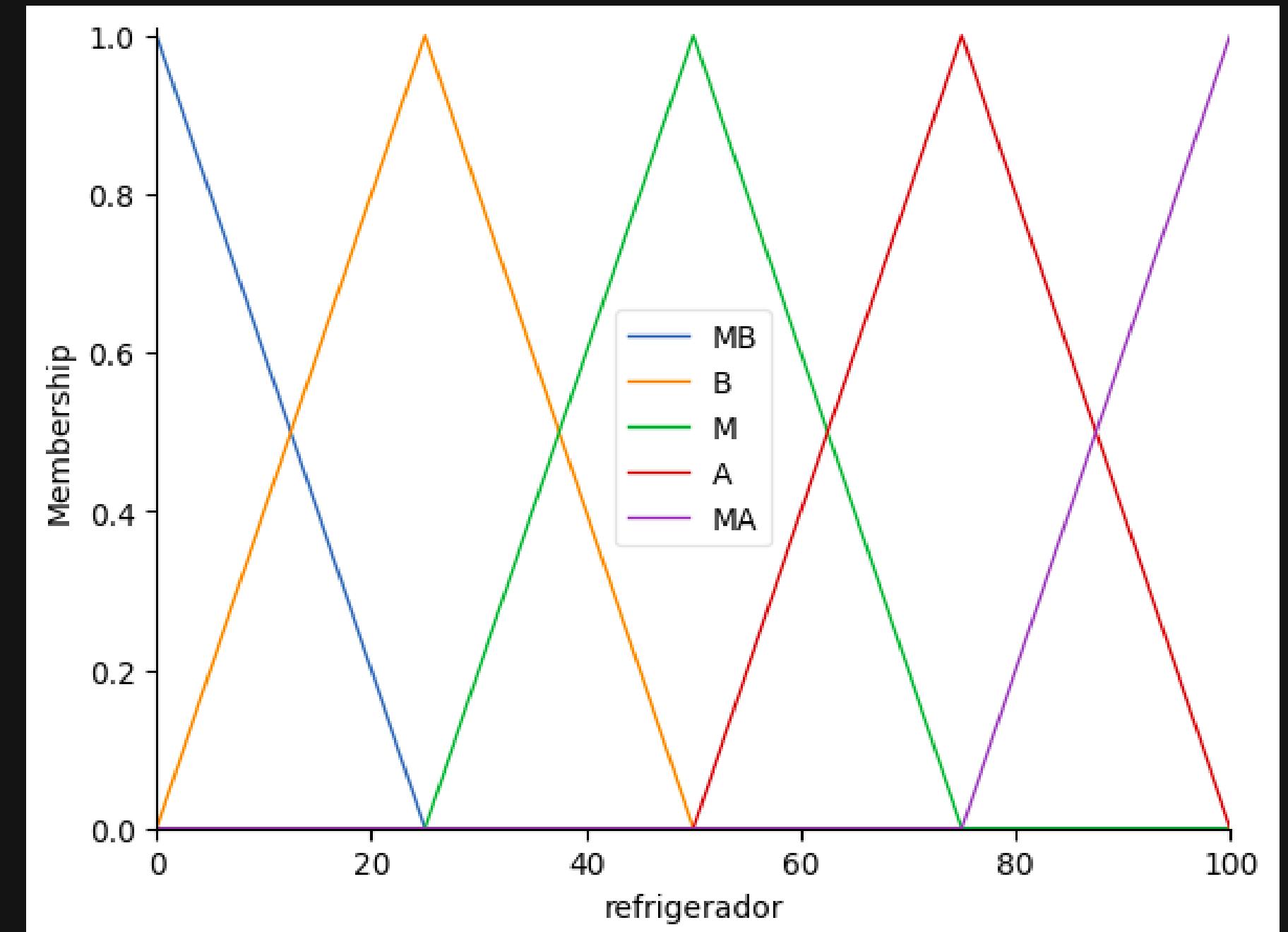


# Saída do Refrigerador



```
refrigerador = ctrl.Consequent(np.arange(0, 101, 1), 'refrigerador')

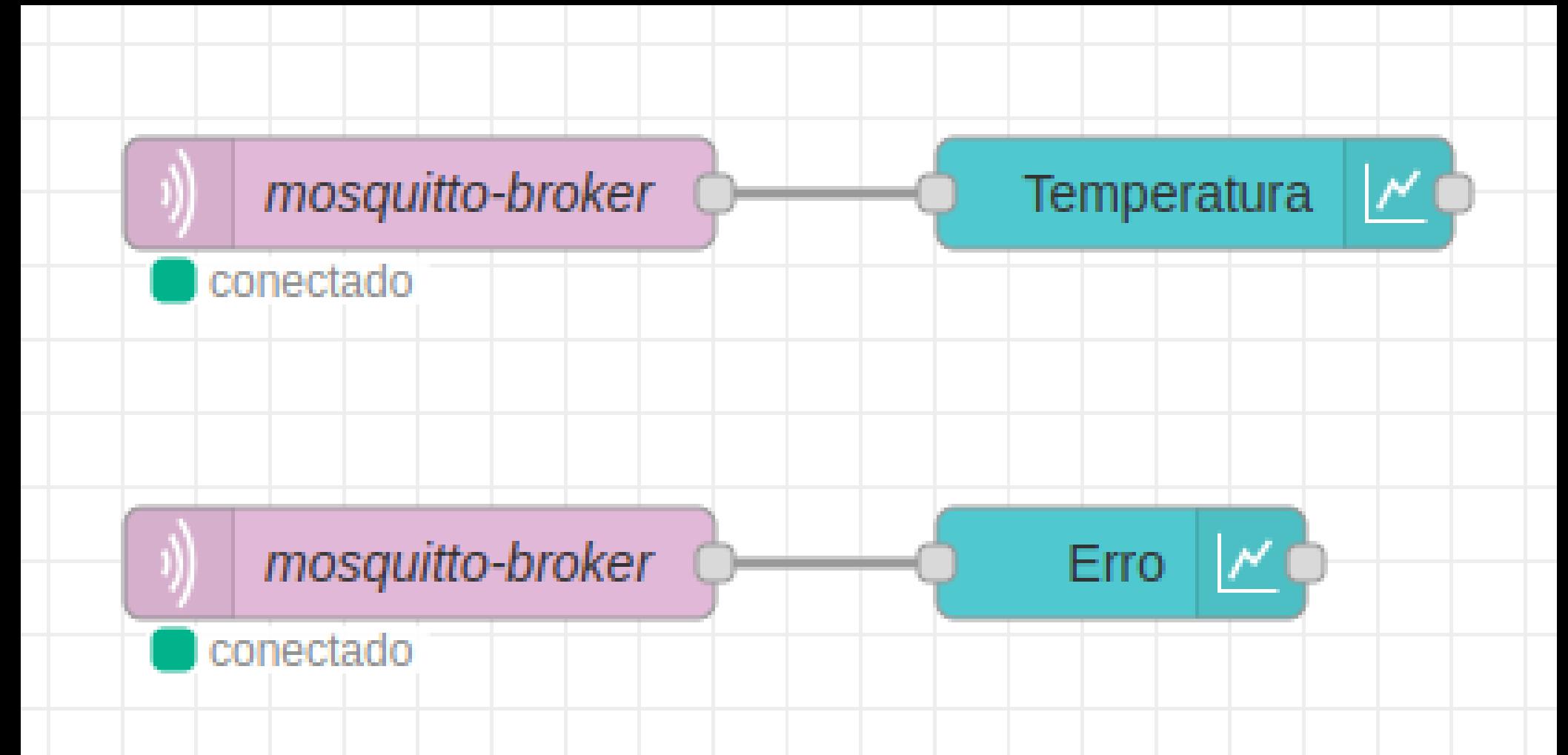
refrigerador['MB'] = fuzz.trimf(refrigerador.universe, [0, 0, 25])      # MUITO BAIXO
refrigerador['B'] = fuzz.trimf(refrigerador.universe, [0, 25, 50])        # BAIXO
refrigerador['M'] = fuzz.trimf(refrigerador.universe, [25, 50, 75])       # MÉDIO
refrigerador['A'] = fuzz.trimf(refrigerador.universe, [50, 75, 100])        # ALTO
refrigerador['MA'] = fuzz.trimf(refrigerador.universe, [75, 100, 100])     # MUITO ALTO
```



# Tabela de Regras

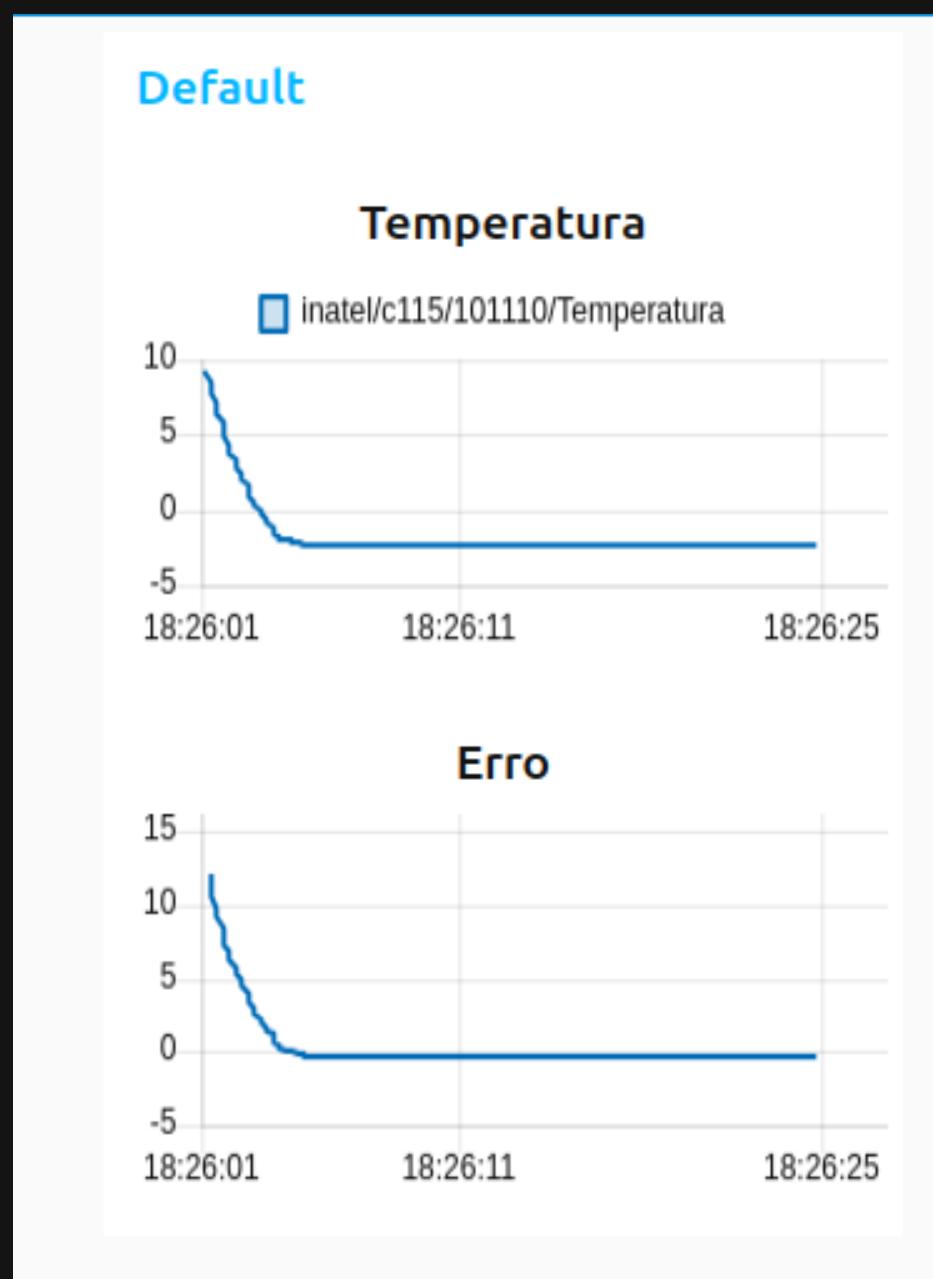
Erro / Variação do Erro	MP	P	Z	N	MN
MP	MA	MA	MA	A	A
P	MA	A	MA	M	A
Z	A	A	M	B	MB
N	B	M	MB	B	MB
MN	B	B	MB	MB	MB

# Interface Gráfica (Node-Red)



# Gráficos da Temperatura e do Erro

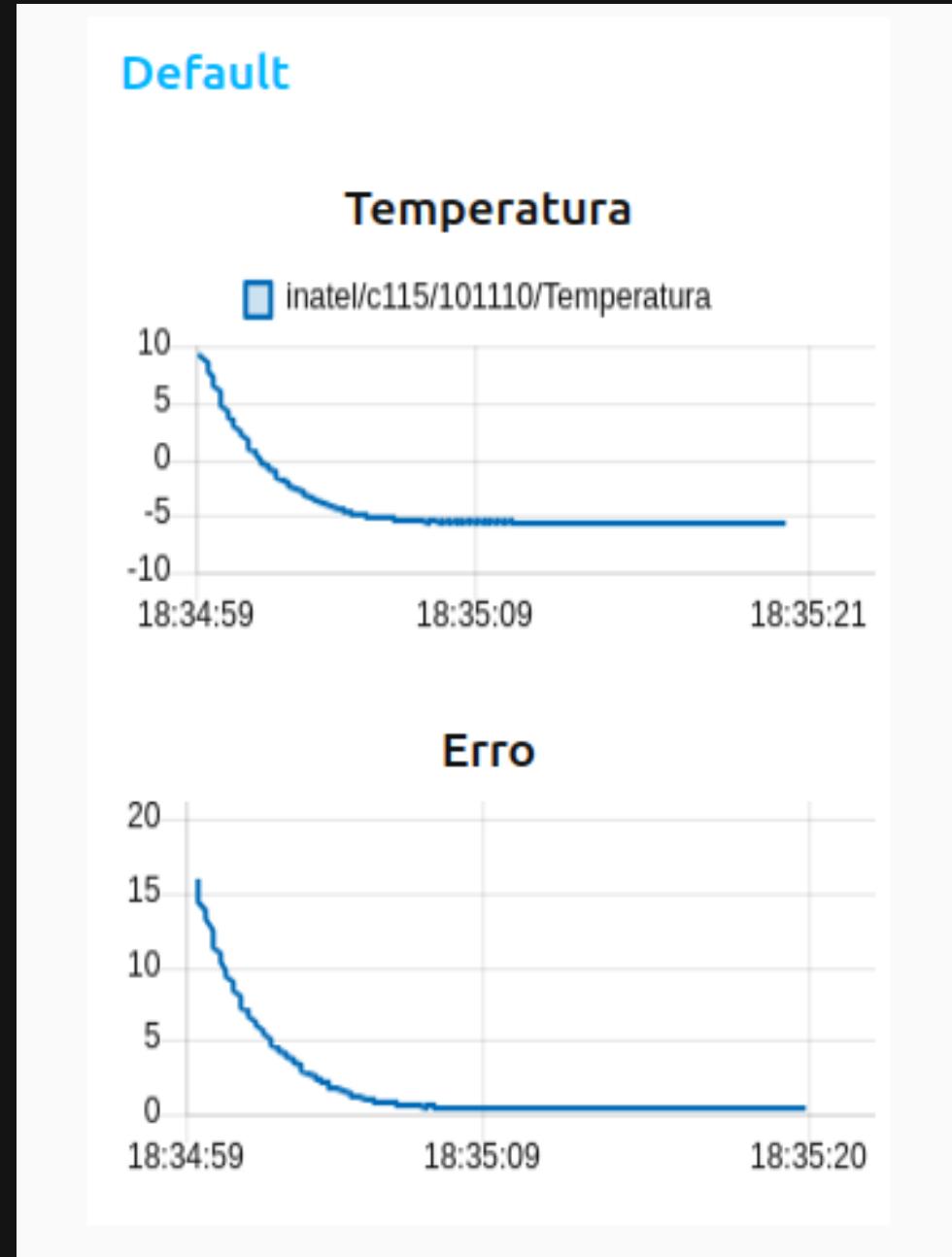
Setpoint = -2°C    Temperatura Inicial = 10°C



10  
9.174708538541172  
8.452827695035545  
7.764858186057946  
7.10920698054263  
6.484355882225007  
5.888858014175073  
5.321334468474657  
4.780471113280639  
4.265015549880716  
3.77377421269561  
3.3056096055126196  
2.8594376675508637  
2.434225263259185  
2.028987790034215  
1.6427868983191363  
1.2747283188039118  
0.9239597916957284  
0.5896690932647887  
0.27108215509578953  
-0.032538728309872846  
-0.3218966077315758  
-0.5976615071820437  
-0.8604719753846353  
-1.1109365643678735  
...  
-2.3739403955199725  
-2.3739403955199725  
-2.3739403955199725  
-2.3739403955199725

# Gráficos da Temperartura e do Erro

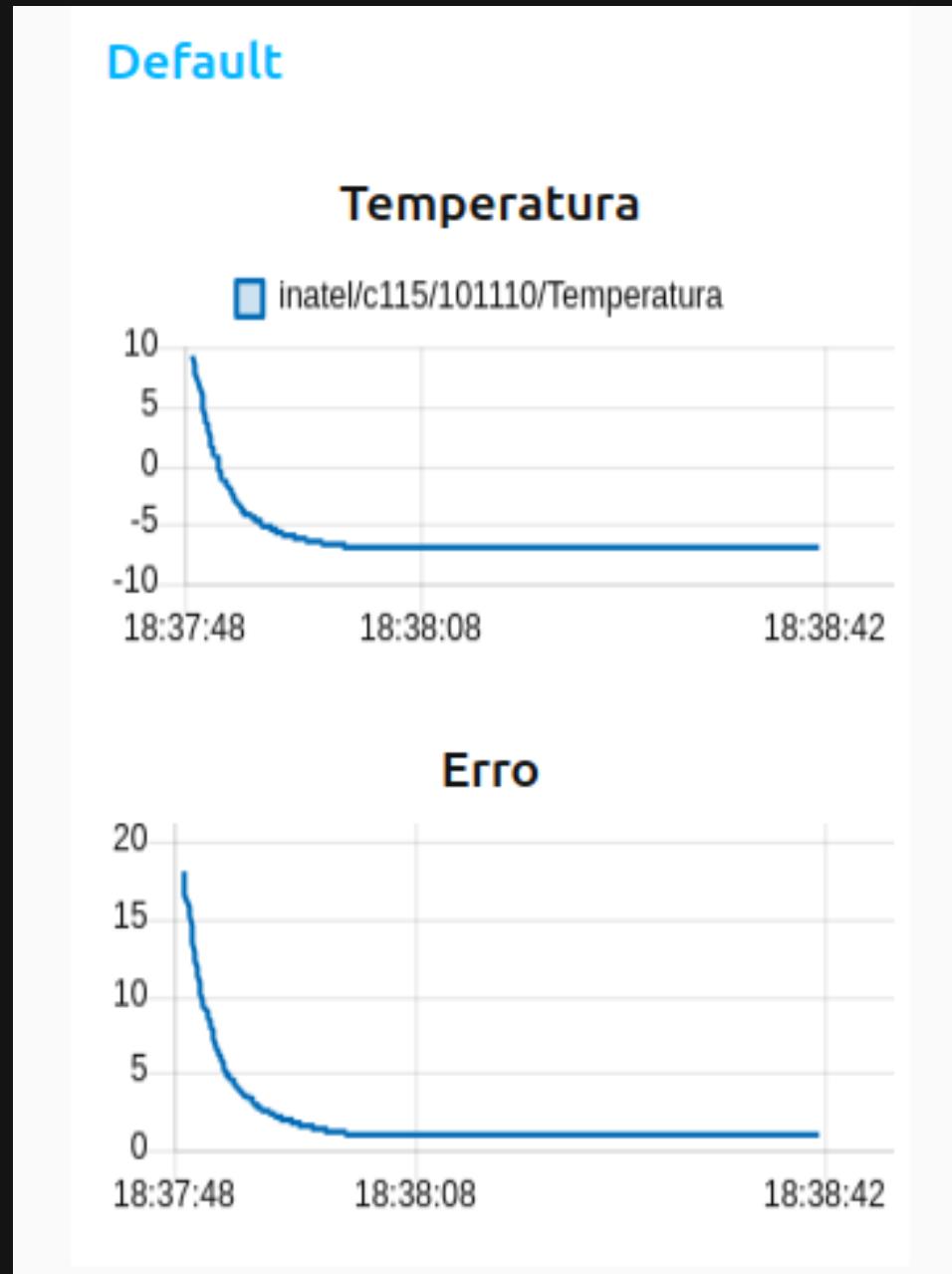
Setpoint = -6°C    Temperatura Inicial = 10°C



10  
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8.452827695035545  
7.764858186057946  
7.10920698054263  
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5.888858014175073  
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4.780471113280639  
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2.434225263259185  
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1.2747283188039118  
0.9239597916957284  
0.5896690932647887  
0.27108215509578953  
-0.032538728309872846  
-0.3218966077315758  
-0.5976615071820437  
-0.8604719753846353  
-1.1109365643678735  
...  
-5.570133343059915  
-5.598675231405491  
-5.570133343059915  
-5.598675231405491

# Gráficos da Temperatura e do Erro

Setpoint = -8°C    Temperatura Inicial = 10°C



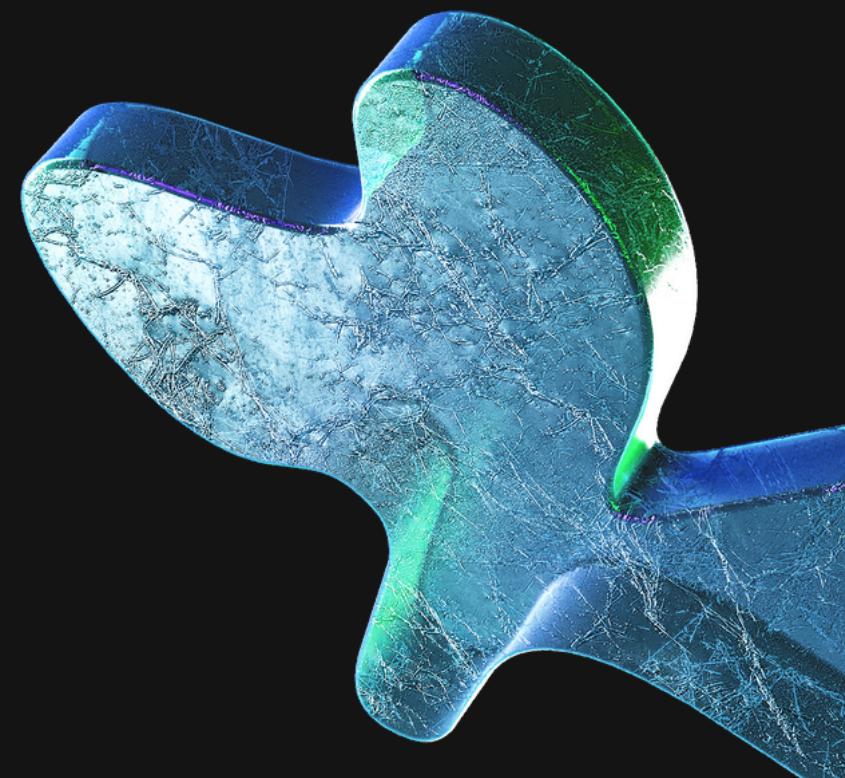
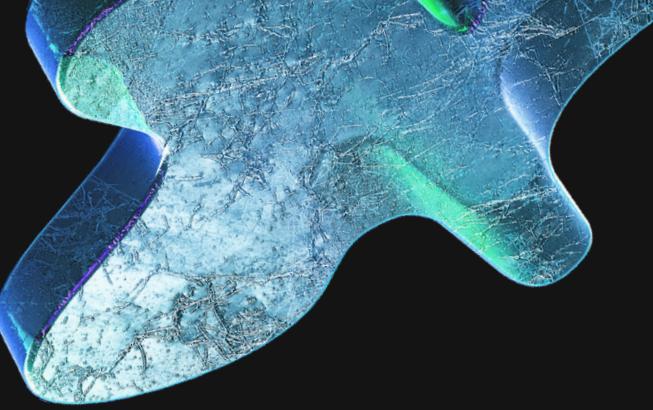
10  
9.174708538541172  
8.452827695035545  
7.764858186057946  
7.10920698054263  
6.484355882225007  
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...  
-7.029986439119737  
-7.008916454618709  
-7.029986439119739  
-7.008916454618711

# Conclusões

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- O sistema em malha fechada atinge a estabilidade em aproximadamente:
  - 5 segundos (10 °C para -2 °C);
  - 15 segundos (10 °C para -8 °C);
- Ao ajustar a tolerância na variação do erro, possibilita-se que a resposta seja mais/menos agressiva;
- A tolerância do erro admitida durante o processo de “Considerações de Projeto” foi atingida;

Obrigado!



# Link do GitHub:



The image shows a screenshot of a GitHub repository page. The repository name is "Joaohsd/fuzzy-control". The description states: "This repository is used to present the development of first work in "C213 - Sistemas Embarcados" subject from INATEL." It has 1 contributor, 0 issues, 0 stars, and 0 forks. The GitHub logo is visible at the bottom right.

**Joaohsd/fuzzy-control**

This repository is used to present the development of first work in "C213 - Sistemas Embarcados" subject from INATEL.

1 Contributor 0 Issues 0 Stars 0 Forks

[GitHub](#)