

# Internet de las abejas



Juan Bernardo Ceballos

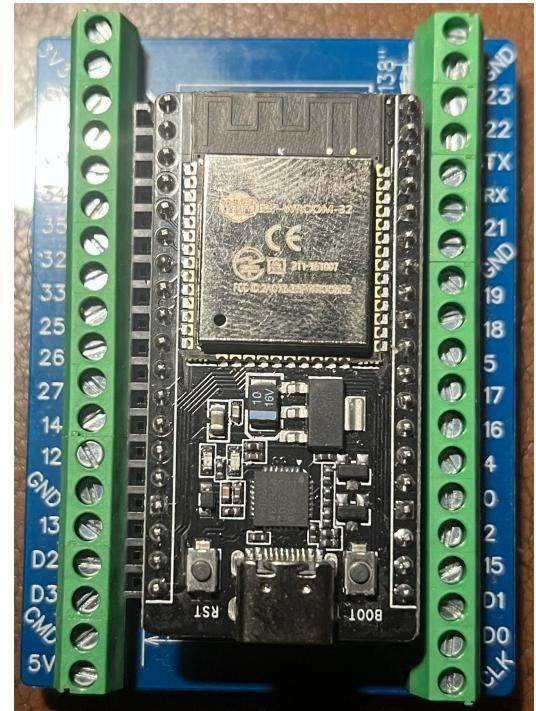
15 agosto 2025

# Objetivos

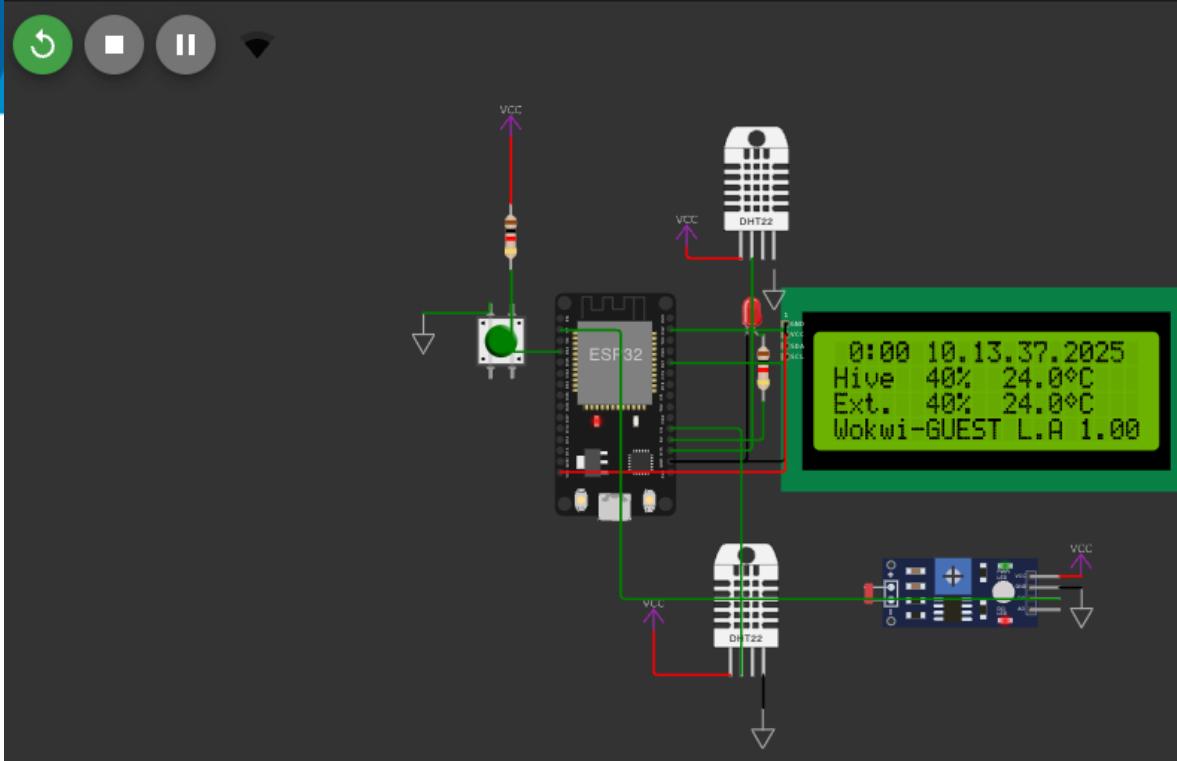
- Identificar problemas de termoregulación en una colmena
- Conocer potencial de ocurrencia de un enjambre
- Impactar mínimamente la colmena

# $\mu$ controlador

- Alimentación
  - Energia solar
  - Bateria
  - Reducción de consumo
- Conectividad
  - WiFi
- Conexión de sensores
  - I2C
- Tiempo Real - RTC
- Interrupciones
- Tarjeta SD memoria



# Desarrollo



PROBLEMS    OUTPUT    DEBUG CONSOLE    TERMINAL    PORTS

Humedad ambiente: 40.00% Temperatura externa: 24.00°C  
Luz ambiente (normalizada entre 0 y 1): 1.00  
Presión atmosférica: 0.00hPa

[ 2206] [E] [sd\_diskio.cpp:806] sdcard\_mount(): f\_mount failed: (3) The physical drive cannot work  
[ 2716] [E] [sd\_diskio.cpp:126] sdSelectCard(): Select Failed  
Card Mount Failed

Adicionando al archivo: /colmena.csv  
[ 2723] [E] [vfs\_api.cpp:24] open(): File system is not mounted

Failed to open file for appending  
Adicionado a la SD: 0,0,0,0,0,24.00,40.00,24.00,40.00,0.00,1.00

1 redes encontradas.  
1: Wokwi-GUEST (-97)

WiFi connected: Wokwi-GUEST -91  
ESP32 tiene el IP 10.13.37.2

IP del Gateway: 10.13.37.1  
192.168.18.212 tiempo de respuesta del HOST MacBook : 0/20.17/0 ms

Enviar POST a la Web

El cliente esp32-client-24:0A:C4:00:01:10 está conectado al MQTT broker

Enviar POST al HOST de la base de datos

Conectado exitosamente a EMQX  
Reiniciando el temporizador del Watchdog  
Respuesta HTTP al POST del servidor remoto: 200

# Software

- Sistema ejecutivo tiempo real
  - Pre-emptive scheduling
  - Procesos
- MQTT
- MySQL
- POST
- Watchdog



# Datos en memoria *Secure Digital SD*

```
Total space: 120534MB  
Used space: 4MB
```

```
Adicionando al archivo: /colmena.csv  
Lectura adicionada al SD  
Adicionado a la SD: 25,3,27,17,43,45,23.10,71.10,23.50,68.60,818.52,0.82
```

```
3 redes encontradas.  
1: HomeNet (-53)*  
2: ENTELHOGAR-475 (-87)*  
3: HomeNet (-96)*
```

```
WiFi connected: HomeNet -52  
ESP32 tiene el IP 192.168.18.249  
IP del Gateway: 192.168.18.1  
192.168.18.212 tiempo de respuesta del HOST MacBook : 0/534.40/0 ms  
El cliente esp32-client-08:A6:F7:B1:A0:D4 está conectado al MQTT broker  
Enviar POST a la Web  
Enviar POST al HOST de la base de datos  
Conectado exitosamente a EMQX  
Reiniciando el temporizador del Watchdog  
Interrupción recibida
```

```
Leyendo archivo: /colmena.csv  
Contenido del archivo:  
Colmena Altos de Cantaclaro  
Juan Bernardo Ceballos  
Latitud: 2°30'40.1 Norte Longitud: 76°33'20.5 Oeste Elevacion: 1820 metros  
Year, Month, Day, Hour, Minute, Second, Hive Temperature (°C), Hive Humidity (%), Ambient Temperature (°C), Ambient Humidity (%), Atmospheric pressure hPa, Luminic index (normalized)  
25,3,18,17,13,17,24.60,62.30,22.60,69.10,819.54,0.45  
25,3,18,17,13,41,24.60,62.00,22.80,68.90,819.56,0.48  
25,3,18,17,14,5,24.60,61.80,22.70,68.50,819.56,0.48  
25,3,18,17,15,20,24.60,62.20,22.60,69.00,819.58,0.43  
25,3,18,17,15,53,24.60,62.30,22.60,69.60,819.60,0.42  
25,3,18,17,16,17,24.60,62.40,22.70,69.10,819.58,0.39  
25,3,18,17,16,41,24.50,62.00,22.60,69.10,819.59,0.40  
25,3,18,17,17,29,24.50,62.30,22.60,69.10,819.59,0.37  
25,3,18,17,18,27,24.60,62.30,22.60,69.00,819.62,0.35  
25,3,18,17,18,51,24.50,61.90,22.60,68.80,819.61,0.35  
25,3,18,17,19,15,24.50,62.30,22.50,69.50,819.63,0.32
```

# Implementación



# Implementación



17:11 Ceballos 2025  
Hive 90.60% 21.40C  
Ext. 85.50% 20.40C  
P 819.26hPa L.A 0.63

# Colmena Altos de Cantaclaro - Juan Ceballos

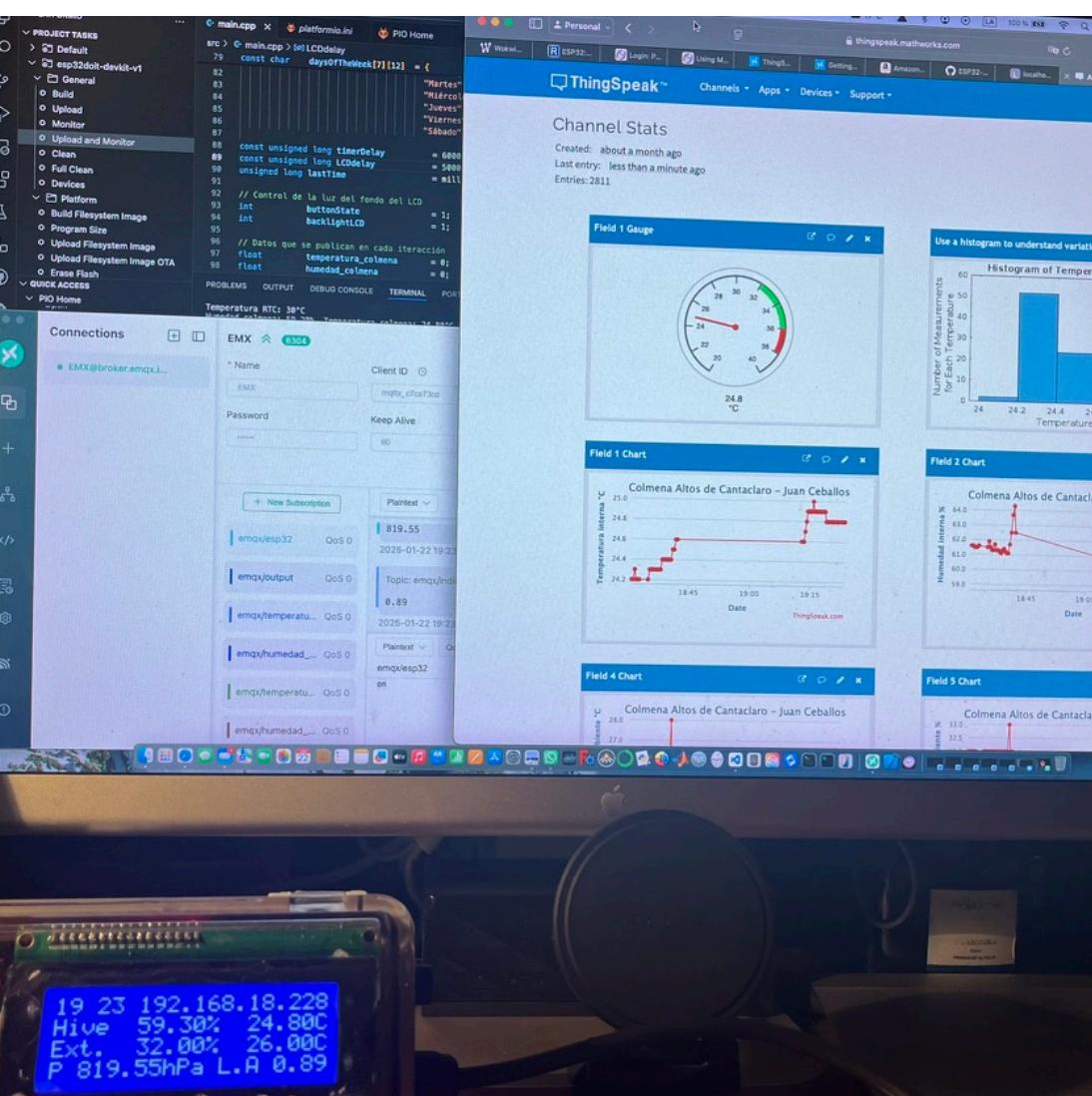
Channel ID: 2786368

Author: cebajub

Access: Public

Export recent data

MATLAB Analysis



# Base de datos

```
mysql> SELECT * FROM colmena;
```

id   hora   t_colmena   h_colmena   t_ambiente   h_ambiente   presion   luz
1   2025-02-23 10:17:51   21.6   71.5   24.6   60.2   821.91   0.93
2   2025-02-23 10:18:51   21.6   71.5   24.6   59.8   821.9   0.93
3   2025-02-23 10:19:51   21.7   71   24.6   60.1   821.87   0.96
4   2025-02-23 10:20:52   21.7   70.5   24.6   59.6   821.88   0.96
5   2025-02-23 10:22:37   22   70.4   24.7   59.1   821.86   0.96
6   2025-02-23 10:23:38   22.4   69.4   24.7   58.6   821.84   0.96
7   2025-02-23 10:24:38   22.6   68.4   24.6   58.6   821.8   0.95
8   2025-02-23 10:25:38   22.8   68.5   24.6   59.1   821.81   0.96
9   2025-02-23 10:27:56   23   68   24.6   60.7   821.84   0.96
10   2025-02-23 10:28:56   23.3   65.4   24.6   58.7   821.79   0.91
11   2025-02-23 10:32:05   23.4   65.4   24.5   59.2   821.73   0.93
12   2025-02-23 10:34:06   23.4   66   24.4   59.9   821.69   0.93
13   2025-02-23 10:36:06   23.2   65.1   24.3   59.3   821.74   0.95
14   2025-02-23 10:37:06   23.2   64.8   24.3   58.8   821.73   0.96
15   2025-02-23 10:38:06   23.2   64.1   24.3   58.5   821.69   0.97
16   2025-02-23 10:40:06   23.3   62.8   24.3   56.4   821.65   0.94
17   2025-02-23 10:41:07   23.5   63.4   24.5   57.2   821.65   0.96
18   2025-02-23 10:42:07   23.6   62.9   24.6   56.8   821.68   0.95
19   2025-02-23 10:45:08   23.9   62.3   24.9   57.1   821.61   0.98
20   2025-02-23 10:48:07   24.3   61   25.2   58.1   821.64   0.95
21   2025-02-23 10:50:07   24.4   60.7   25.3   58.1   821.58   0.95
22   2025-02-23 10:52:09   24.4   60.7   25.2   58.3   821.59   0.93
23   2025-02-23 10:54:09   24.4   61.3   25.2   58.3   821.53   0.95
24   2025-02-23 11:08:18   24.2   62   26.1   56.6   821.39   0.94
25   2025-02-23 11:10:18   24.2   61.9   26.2   56   821.33   0.94
26   2025-02-24 15:12:55   23.7   67.2   25.3   62.7   817.66   0.8

# MQTT - Message Queuing Telemetry Transport

Topic: emqx/trama QoS: 0

Year, Month, Day, Hour, Minute, Second, Hive Temperature (°C), Hive Humidity (%), Ambient Temperature (°C),  
Ambient Humidity (%), Atmospheric pressure (hPa), Luminic index (normalized)

2025-03-20 14:07:49:278

Topic: emqx/trama QoS: 0

25,3,20,14,8,26,25.6,64,26.8,60,818.41,0.96

2025-03-20 14:08:44:719

Topic: emqx/trama QoS: 0

25,3,20,14,9,15,25.6,64,26.7,60,818.42,0.96

2025-03-20 14:09:45:503

2025-03-20 04:22:22:613

Topic: emqx/temperatura\_colmena QoS: 0

25.6

2025-03-20 14:08:44:694

Topic: emqx/temperatura\_colmena QoS: 0

25.6

2025-03-20 14:09:45:474

Topic: emqx/temperatura\_colmena QoS: 0

23.4

2025-03-20 19:48:41:134

Topic: emqx/temperatura\_colmena QoS: 0

22.8

2025-03-21 08:48:59:975

## Datos de la colmena

ID	Hora	Temperatura Colmena	Humedad Colmena	Temperatura Ambiente	Humedad Ambiente	Presion atmosferica	Indice luminico
291	2025-03-26 16:30:16	24	40	24	40	0	1
290	2025-03-26 16:29:27	24	40	24	40	0	1
289	2025-03-26 15:03:35	28	53.5	29.2	50.7	817.35	0.86
288	2025-03-26 15:02:47	28.1	53.3	29.2	50.5	817.38	0.85
287	2025-03-26 14:59:54	28.1	51.8	29.3	48.6	817.41	0.89
286	2025-03-26 14:28:11	27.8	55.9	29.2	52.6	818.04	0.93
285	2025-03-26 14:27:23	27.8	55.9	29.2	53.4	818.08	0.6
284	2025-03-26 14:22:07	27.1	56.9	28.1	54.2	818.15	0.97
283	2025-03-26 14:21:17	26.9	57.5	27.7	55.6	818.19	0.95
282	2025-03-21 08:50:24	22.9	65.4	23.5	63.2	821.43	0.96
281	2025-03-21 08:49:35	22.8	65.5	23.4	64.1	821.43	0.95
280	2025-03-20 19:50:06	23.4	71.3	24.6	67.6	820.3	0
279	2025-03-20 19:49:18	23.4	71.3	24.6	68	820.3	0
278	2025-03-20 19:46:32	23.4	71.3	24.6	67.1	820.34	0
277	2025-03-20 14:09:26	25.6	63.7	26.7	59.6	818.42	0.96
276	2025-03-20 14:08:37	25.6	64	26.8	60.1	818.41	0.96
275	2025-03-20 13:55:42	25.2	65.8	28.8	56.7	818.68	0.94
274	2025-03-20 13:54:53	25.2	66.1	29	57.8	818.72	0.95
273	2025-03-20 13:46:59	24.7	66.5	26.1	61.8	818.78	0.93
272	2025-03-20 13:46:10	24.7	66.3	26	62	818.76	0.94
271	2025-03-20 13:22:09	24.4	66.5	25.7	62.2	819.36	0.93
270	2025-03-20 13:19:56	24.5	66.7	25.9	62.1	819.36	0.93
269	2025-03-20 13:19:08	24.5	67	25.9	62.2	819.41	0.92

