

Local Grill Monitoring Setup

System Overview: The **Local Grill Monitoring Setup** provides a 100% self-hosted, cloud-free telemetry and historical graphing pipeline for the **FireBoard 2 (FBX2-GJ8RC3JRD)** 6-probe grill thermometer. The FireBoard 2 itself has **no IP address and no Wi-Fi connection**. Instead, an internal **Seeed Studio XIAO ESP32-C3** bridge (hostname `fireboardctl.drheck.dev`, static DHCP IP `10.0.0.71`, Wi-Fi MAC `80:f1:b2:51:49:20`), switched on and off in hardware by an **IRLB8721PBF** N-Channel MOSFET driven directly from the FireBoard's `[Pin 35: TXD0]` pad, reads all probe channels over Bluetooth Low Energy GATT (`94:54:c5:f7:1c:fa`) and posts live updates over Wi-Fi to <https://grill.drheck.dev> (`http://10.0.0.3:8088/api/ingest`).

1. Hardware Wiring & Flashing Guide (Seeed Studio XIAO ESP32-C3 + IRLB8721PBF MOSFET)

1.1 Parts Used

- **Microcontroller** (`fireboardctl.drheck.dev`): **Seeed Studio XIAO ESP32-C3** (\$21\text{ mm} \times 17.5\text{ mm}\$, Wi-Fi STA MAC `80:f1:b2:51:49:20`, static DHCP IP `10.0.0.71`, built-in Li-Ion battery pads on underside + external `U.FL` antenna socket).
- **External Antenna:** Included **Seeed `U.FL` (IPEX) 2.4 GHz flexible dipole sticker antenna** (snap onto the XIAO's `ANT` socket before powering on; adhere inside the plastic FireBoard shell away from the metal Li-Ion pouch cell).
- **Hardware Power Switch MOSFET:** **IRLB8721PBF** TO-220 Logic-Level N-Channel MOSFET ($V_{GS(th)} = 1.35\text{ V}$, $R_{DS(on)} \approx 0.013\text{ }\Omega$ at $V_{GS} = 3.3\text{ V}$).

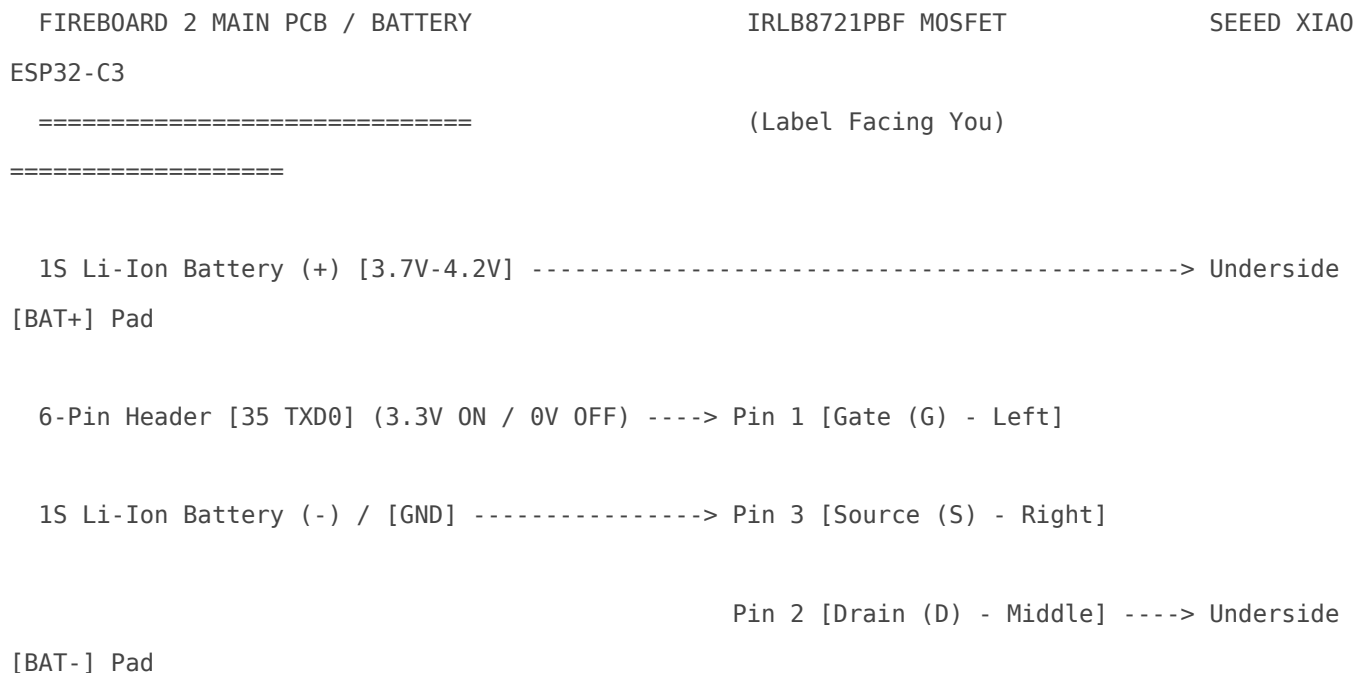
1.2 Step-by-Step Pin Connections (4 Wires Total)

MOSFET Pin Orientation (IRLB8721PBF): Hold the MOSFET with the **black printed label facing you** and the **metal heatsink tab facing away** (legs pointing down). From left to right, the 3 legs are:

- **Pin 1 (Left Leg):** Gate (G) — Trigger input (3.3 V ON / 0.0 V OFF)
- **Pin 2 (Middle Leg):** Drain (D) — Switched ground going to XIAO BAT-
- **Pin 3 (Right Leg):** Source (S) — True ground going to FireBoard Battery - (GND)

1. **Wire 1 (BAT+ Power):** FireBoard Battery + (Red) $\rightarrow$ XIAO underside BAT+ pad.
2. **Wire 2 (Source Ground):** FireBoard Battery - (Black / GND) $\rightarrow$ MOSFET Pin 3 (Right Leg, Source).
3. **Wire 3 (Drain Switched Ground):** MOSFET Pin 2 (Middle Leg, Drain) $\rightarrow$ XIAO underside BAT- pad.
4. **Wire 4 (Gate 3.3V Trigger):** FireBoard 6-pin header top-left pad ([Pin 35: TXD0]) $\rightarrow$ MOSFET Pin 1 (Left Leg, Gate).
 - When the FireBoard 2 is turned **ON**, [Pin 35: TXD0] outputs 3.30 V , turning the IRLB8721PBF MOSFET **ON** and connecting the XIAO's BAT- pad to ground so the XIAO boots immediately.
 - When the FireBoard 2 is turned **OFF**, [Pin 35: TXD0] drops to 0.00 V , turning the IRLB8721PBF MOSFET **OFF** and completely disconnecting the XIAO from the battery (0.000 mA standby drain).

1.3 Complete 4-Wire Schematic



Why Power Connects to the Underside BAT+ / BAT- Pads (Not the Top 5V Pin): On the Seeed Studio XIAO ESP32-C3, the top 5V (VBUS) pin passes through a protection

Schottky diode ($\Delta V_{\text{diode}} \approx 0.34 \text{ V}$) before feeding the XC6206P332MR 3.3 V LDO ($\Delta V_{\text{drop}} \approx 0.25 \text{ V}$), requiring at least 3.85 V on 5V before the 3.3 V rail sags. Soldering to the **underside** BAT+ pad bypasses the Schottky diode and feeds the LDO directly ($V_{\text{min}} = 3.30 \text{ V} + 0.25 \text{ V} = 3.55 \text{ V}$), running cleanly across the entire $3.5 \text{ V} \rightarrow 4.2 \text{ V}$ discharge curve of the 1S Li-Ion cell.

1.4 Building, Flashing & Bench Testing (PlatformIO)

1. Snap the U.FL antenna onto the XIAO ESP32-C3 before powering on.
2. Copy include/secrets.example.h to include/secrets.h in ~/git/grill-sync and set your 2.4 GHz Wi-Fi credentials:

```
#define WIFI_SSID "Your_2.4GHz_WiFi_SSID"
#define WIFI_PASSWORD "Your_WiFi_Password"
```

3. Compile, flash over USB-C, and open the live serial monitor (115200 baud):

```
$ pio run -t upload -t monitor
```

4. Turn on the FireBoard 2 nearby with a probe plugged into Channel 1. Within 5 seconds, the serial console outputs:

```
=== FireBoard 2 BLE -> Wi-Fi Sync (fireboardctl.drheck.dev) ===
[Wi-Fi] Connected, IP: 10.0.0.71, MAC: 80:F1:B2:51:49:20
[BLE] Found FireBoard (94:54:c5:f7:1c:fa, RSSI -42 dBm)
[BLE] Connected to FireBoard 2
[BLE] Subscribed and sent 0x01 start command
[BLE] Ch 1: 72.5 F
[HTTP] POST http://10.0.0.3:8088/api/ingest -> 200
```

2. FireBoard 2 Hardware Forensics & PCB Pinout Reference

2.1 Internal ESP32-WROVER-E Photograph & Pin Labels

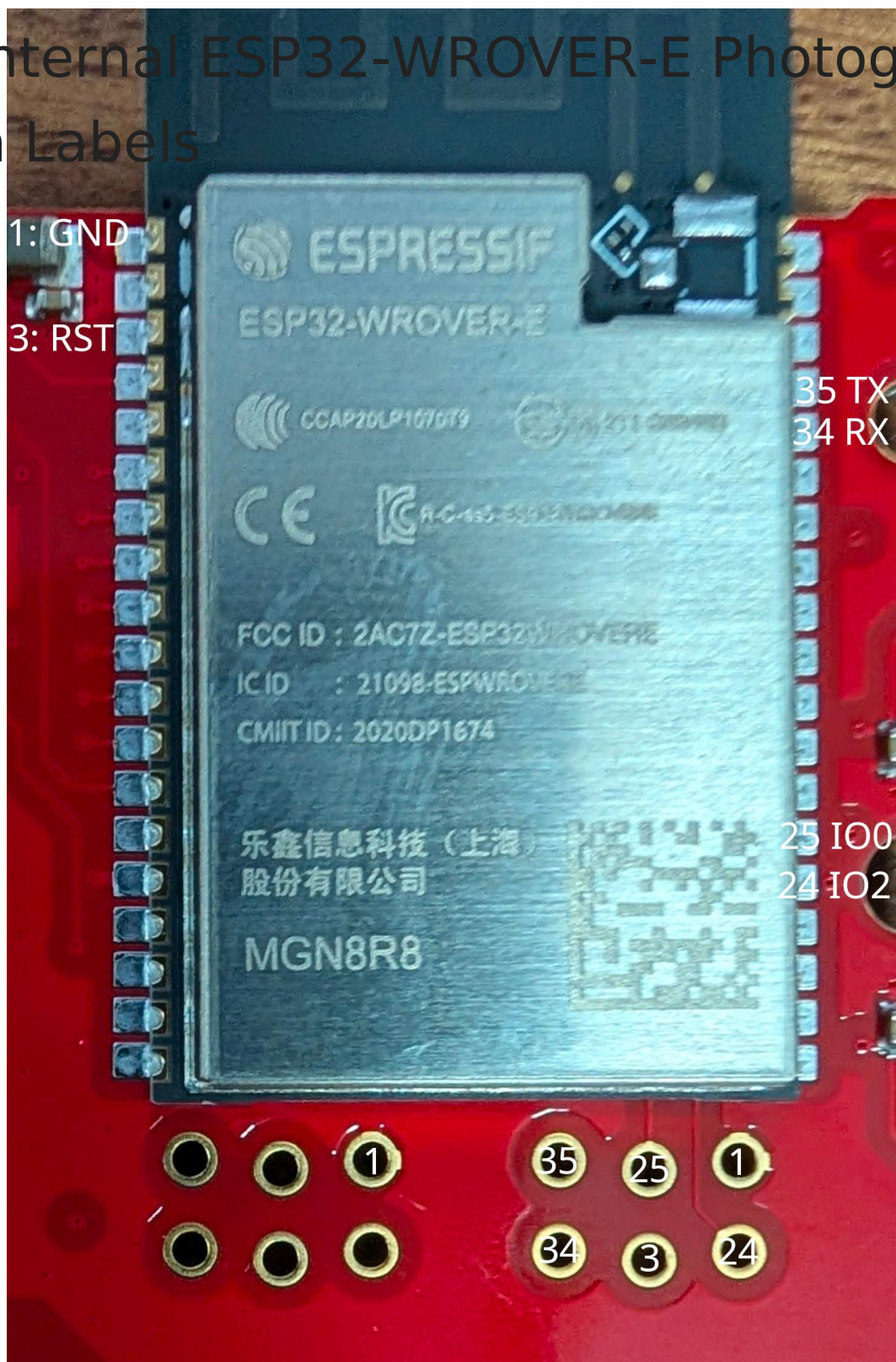


Figure 1: FireBoard 2 internal ESP32-WROVER-E (MGN8R8) module and unpopulated 6-pin 1.27mm UART bootloader header with verified pin numbers.

2.2 Unpopulated 6-Pin 1.27mm (0.050") Debug Header Pinout

Located immediately below the ESP32-WROVER-E module on the main PCB. All pads were verified by continuity against the castellated ESP32-WROVER-E pins:

TOP ROW (Closer to ESP32 bottom edge)

[Pin 35] *	[Pin 25]	[GND]
UART0 TXD0	GPI00 (BOOT)	Ground
(Right #23)	(Right #14)	(Shield/1/15)

BOTTOM ROW (Closer to PCB edge)

[Pin 34]	[Pin 3]	[Pin 24]
UART0 RXD0	EN / RST	GPI02 (Strap)
(Right #22)	(Left #3)	(Right #13)

* [Pin 35: TXD0] (top-left pad) outputs 3.30V when FireBoard is ON and 0.00V when FireBoard is OFF – wire this pad to MOSFET Pin 1 (Gate).

Header Pad	ESP32 Module Pin	Function	Voltage (FireBoard ON)	Voltage (FireBoard OFF)	Notes
[35 TXD0]	Pin 35 (Right #23)	GPI01 / U0TXD	\$3.30\text{ V}\$ (Idle High)	\$0.00\text{ V}\$	Used as the \$3.3\text{ V}\$ ON/OFF trigger for MOSFET Pin 1 (Gate)
[34 RXD0]	Pin 34 (Right #22)	GPI03 / U0RXD	\$3.30\text{ V}\$	\$0.00\text{ V}\$	UART0 receive input
[25 I00]	Pin 25 (Right #14)	GPI00 (Boot Strap)	\$3.30\text{ V}\$	\$0.00\text{ V}\$	Hold at \$0\text{ V}\$ (GND) while pulsing [3 RST] to enter UART Download Mode
[3 RST]	Pin 3 (Left #3)	CHIP_PU (EN / RST)	\$3.30\text{ V}\$	\$0.00\text{ V}\$	Active-low hardware reset (\$0\text{ V}\$ resets ESP32)
[24 I02]	Pin 24 (Right #13)	GPI02 (Boot Strap)	\$0.00\text{ V}\$	\$0.00\text{ V}\$	Must be low/floating to enter serial bootloader
[GND]	Pins 1, 15, 38, 39	Common Ground	\$0.00\text{ V}\$	\$0.00\text{ V}\$	Connected to ESP32 RF shield can and battery negative (-)

Additional Module Reference Pad: `Left #2 ( Pin 2: 3V3 )` carries the regulated `$3.30\text{ V}` rail when the FireBoard is powered on and drops to `$0.00\text{ V}` when powered off.

2.3 Hardware & Network Identity Reference

Device / Component	Property	Value	Notes
XIAO ESP32-C3 Bridge	Hostname (FQDN)	<code>fireboardctl.drheck.dev (fireboardctl)</code>	Only device on Wi-Fi; resolved in Unbound on <code>danknasty</code>
XIAO ESP32-C3 Bridge	Static DHCP IPv4	<code>10.0.0.71</code>	Reserved in <code>/etc/dhcpd.conf (~/git/router_config/dhcpd.conf)</code> on <code>danknasty</code>
XIAO ESP32-C3 Bridge	Wi-Fi STA MAC	<code>80:f1:b2:51:49:20</code>	Seed Studio XIAO ESP32-C3 2.4 GHz Wi-Fi interface
FireBoard 2 Unit	Device ID / Serial	<code>FBX2-GJ8RC3JRD</code>	FireBoard 2 6-Channel Thermometer (<code>ESP32-WROVER-E / ESP32-D0WD-V3 rev v3.1</code>)
FireBoard 2 Unit	Bluetooth LE MAC (Base + 2)	<code>94:54:c5:f7:1c:fa</code>	Active whenever the FireBoard 2 is powered on
FireBoard 2 Unit	Wi-Fi STA MAC (Base)	<code>94:54:c5:f7:1c:f8</code> (Unconfigured / No IP)	FireBoard 2 is not connected to Wi-Fi and holds no IP address
FireBoard 2 Unit	Battery Pack	<code>1S Li-Ion Pouch Cell</code> (<code>\$3.7\text{ V}</code> nominal, <code>\$4.20\text{ V}</code> full)	Powers both the FireBoard 2 and the <code>IRLB8721PBF</code> MOSFET-switched XIAO ESP32-C3

2.4 Why the Stock FireBoard Firmware Is Bypassed via BLE

- Closed Local Network Surface:** Full 65,535-port TCP/UDP `nmap` scans and packet captures confirmed the stock FireBoard 2 firmware listens on zero local ports and requires remote cloud servers when on Wi-Fi. Keeping the FireBoard 2 off Wi-Fi and reading its local BLE GATT server eliminates all external network traffic.
- Locked Factory Silicon (eFuses):** Interrogation over the 6-pin UART bootloader header proved all hardware security eFuses on the FireBoard's internal `ESP32-WROVER-E` are permanently burned:
 - Flash Encryption (`FLASH_CRYPT_CNT = 127` / `0b1111111`):** All 7 bits burned and write-protected; plaintext flashing renders the chip unbootable.
 - UART Crypto Disabled (`DISABLE_DL_ENCRYPT = True` , `DISABLE_DL_DECRYPT = True`):** The ROM bootloader is physically barred from encrypting new images or decrypting

flash over UART.

- **Secure Boot v1** (`ABS_DONE_0 = True`): Only images signed with FireBoard's private key (`BLOCK2` , read/write protected) are booted.
- **Silent UART Console** (`MTDO Strapped Low` + `ESP_LOG_NONE`): Zero application log bytes are emitted on `UART0` during normal boot.

Click to expand full ESP32-D0WD-V3 Security eFuse Register Dump (espefuse summary)

FLASH_CRYPT_CNT	(BLOCK0) = 127 R/- (0b1111111)	[Flash encryption permanently enabled; odd bit count = 7; Write-Protected]
FLASH_CRYPT_CONFIG	(BLOCK0) = 15 R/W (0xf)	[Full AES flash encryption tweak configuration]
ABS_DONE_0	(BLOCK0) = True R/W	[Secure Boot V1 permanently enforced on boot]
DISABLE_DL_ENCRYPT	(BLOCK0) = True R/W	[UART bootloader flash encryption disabled]
DISABLE_DL_DECRYPT	(BLOCK0) = True R/W	[UART bootloader flash decryption disabled]
DISABLE_DL_CACHE	(BLOCK0) = True R/W	[UART bootloader MMU flash cache disabled]
JTAG_DISABLE	(BLOCK0) = True R/W	[Hardware JTAG debugging permanently disabled]
CONSOLE_DEBUG_DISABLE	(BLOCK0) = True R/W	[ROM BASIC fallback console disabled]
BLOCK1 (Flash Key)	= ?? ?? ... -/-	[256-bit AES Flash Encryption Key: Read & Write Protected]
BLOCK2 (Secure Boot Key)	= ?? ?? ... -/-	[256-bit Secure Boot Key: Read & Write Protected]

3. FireBoard 2 BLE GATT Protocol Reference

Zero Cloud Dependency: The FireBoard 2 BLE GATT server remains active with zero Wi-Fi configuration, allowing the XIAO ESP32-C3 (`fireboardctl.drheck.dev`) to stream all 6

channels locally.

GATT Attribute	UUID / Value	Properties	Description
FIREBOARD_DATA_CHAR_UUID	c2f780ec-45e1-452b-a879-327e3140d1f1	Notify	Streams UTF-8 JSON temperature packets every 3–5s per active probe channel
FIREBOARD_CONTROL_CHAR_UUID	c2f780ec-45e1-452b-a879-327e3140d1e8	Write	Writing single byte 0x01 starts the notification stream on d1f1
FIREBOARD_START_STREAM_BYTE	0x01 (b'\x01')	1 Byte	Must be written after enabling notifications (CCCD) on d1f1

BLE Handshake & Notification Payload Format

- Scan & Connect:** Connect to BLE MAC 94:54:c5:f7:1c:fa (or any device matching prefix 94:54:c5:f7:1c: / name FBX). No pairing PIN or bond is required.
- Subscribe:** Enable GATT notifications on c2f780ec-45e1-452b-a879-327e3140d1f1.
- Start Stream:** Write 0x01 (1 byte, with response) to c2f780ec-45e1-452b-a879-327e3140d1e8.
- Parse JSON Notifications:** The FireBoard immediately begins emitting UTF-8 JSON notifications for each connected thermistor probe (channel 1 through 6):

```
{
  "channel": 1,
  "temp": 225.4,
  "degreetype": 2,
  "date": "2026-09-28T20:30:00Z"
}
```

- channel: Probe port number (1..6).
- temp: Floating-point temperature (null or <= 0 when unplugged).
- degreetype: 2 = Fahrenheit (°F), 1 = Celsius (°C).

4. Firmware Repository (~/.git/grill-sync) & Magic Constants (include/config.h)

All hardware, BLE protocol, and network constants are isolated in `include/config.h` (with Wi-Fi credentials in gitignored `include/secrets.h`).

Repository Layout

- `platformio.ini` — PlatformIO configuration targeting `seeed_xiao_esp32c3` (`huge_app.csv` 3.1 MB partition table, `NimBLE-Arduino`, `ArduinoJson`).
- `include/config.h` — Central configuration file containing all network URLs, bridge identity (`fireboardctl.drheck.dev`, `10.0.0.71`, `80:f1:b2:51:49:20`), and BLE GATT UUIDs.
- `include/secrets.example.h` / `include/secrets.h` — Local Wi-Fi credentials (`WIFI_SSID`, `WIFI_PASSWORD`) and optional local overrides.
- `src/main.cpp` — Non-blocking BLE GATT client, JSON parser, and HTTP POST transmitter.

Complete Reference of Constants in

include/config.h

Constant	Default Value	Purpose & When to Change
<code>BRIDGE_DHCP_HOSTNAME</code>	<code>"fireboardctl"</code>	DHCP client hostname announced by the XIAO ESP32-C3.
<code>BRIDGE_FQDN</code>	<code>"fireboardctl.drheck.dev"</code>	Local DNS name in Unbound (<code>10.0.0.71</code>).
<code>BRIDGE_WIFI_MAC</code>	<code>"80:f1:b2:51:49:20"</code>	Wi-Fi STA MAC of the Seeed Studio XIAO ESP32-C3 reserved as <code>10.0.0.71</code> in <code>/etc/dhcpd.conf</code> on <code>danknasty</code> .
<code>BRIDGE_STATIC_IPV4</code>	<code>"10.0.0.71"</code>	Static DHCP IPv4 address assigned to <code>fireboardctl.drheck.dev</code> .
<code>INGEST_URL</code>	<code>"http://10.0.0.3:8088/api/ingest"</code>	Target HTTP POST URL on host <code>u1</code> (<code>10.0.0.3</code> ports <code>8088</code> and <code>8000</code>).
<code>HTTP_POST_INTERVAL_MS</code>	<code>5000UL</code> (<code>5s</code>)	How frequently the XIAO posts temperature snapshots to <code>u1</code> when BLE is connected.
<code>HTTP_HEARTBEAT_INTERVAL_MS</code>	<code>15000UL</code> (<code>15s</code>)	How frequently the XIAO posts status heartbeats when scanning for BLE.
<code>WIFI_CONNECT_TIMEOUT_MS</code>	<code>10000UL</code> (<code>10s</code>)	Maximum time spent waiting for Wi-Fi association per attempt.
<code>FIREBOARD_DEVICE_ID</code>	<code>"FBX2-GJ8RC3JRD"</code>	Device ID reported in JSON payloads to <code>u1</code> .
<code>FIREBOARD_BLE_MAC</code>	<code>"94:54:c5:f7:1c:fa"</code>	Bluetooth LE MAC of the FireBoard 2 (<code>Base MAC + 2</code>). Change if pairing with a replacement FireBoard unit.
<code>FIREBOARD_MAC_PREFIX</code>	<code>"94:54:c5:f7:1c:"</code>	OUI/prefix matched during BLE scanning.

Constant	Default Value	Purpose & When to Change
<code>FIREBOARD_LOCK_TO_MAC</code>	<code>0</code>	Set to <code>1</code> to only connect to <code>FIREBOARD_BLE_MAC</code> , or <code>0</code> to also connect to any nearby device advertising <code>"FBX"</code> / <code>"FireBoard"</code> .
<code>FIREBOARD_DATA_CHAR_UUID</code>	<code>"c2f780ec-45e1-452b-a879-327e3140d1f1"</code>	FireBoard 2 BLE GATT <code>Notify</code> characteristic that outputs JSON temperature readings.
<code>FIREBOARD_CONTROL_CHAR_UUID</code>	<code>"c2f780ec-45e1-452b-a879-327e3140d1e8"</code>	FireBoard 2 BLE GATT <code>Write</code> characteristic that starts the stream when <code>0x01</code> is written.
<code>FIREBOARD_START_STREAM_BYTE</code>	<code>0x01</code>	Magic wake byte written to <code>FIREBOARD_CONTROL_CHAR_UUID</code> upon BLE connect.
<code>FIREBOARD_MAX_CHANNELS</code>	<code>6</code>	Maximum probe channel index (<code>Channels 1..6</code>).
<code>FIREBOARD_PROBE_STALE_MS</code>	<code>30000UL</code> (<code>30s</code>)	Time without a BLE notification before a channel is considered unplugged.

5. Dashboard Infrastructure

Reference on Host `u1` (<https://grill.drheck.dev>)

Component	Path / Address	Details
Public URL (SSO Protected)	https://grill.drheck.dev (https://fireboard.drheck.dev)	Protected by Authentik ForwardAuth (<code>Grill Monitor (FireBoard 2)</code> application tile in user portal)
BLE-to-Wi-Fi Bridge Host	<code>fireboardctl.drheck.dev</code> (<code>10.0.0.71</code> • MAC <code>80:f1:b2:51:49:20</code>)	Seeed Studio XIAO ESP32-C3; static DHCP lease in <code>/etc/dhcpd.conf</code> and local DNS in <code>/var/unbound/etc/unbound.conf</code> on <code>danknasty</code>
Unauthenticated Ingest API	<code>http://10.0.0.3:8088/api/ingest /</code> <code>http://10.0.0.3:8000/api/ingest /</code> <code>https://grill.drheck.dev/api/ingest</code>	Accepts <code>POST</code> JSON (<code>{"device_id": "FBX2-GJ8RC3JRD", "ble_connected": true, "rssi": -42, "probes": {"1": 225.4, "2": 165.2}}</code>)
Podman Quadlet & App Source	<code>/home/docker-</code> <code>data/.config/containers/systemd/grill.container,</code> <code>/data/docker/grill/app.py,</code> <code>/data/docker/grill/static/index.html</code>	Rootless Podman container <code>grill</code> (<code>docker-data</code> , <code>UID 1100</code>) running FastAPI + SQLite + Chart.js live/historical multi-channel dashboard (100% local, zero cloud functionality)
Persistent SQLite Database	<code>/data/docker/grill/data/grill.db</code>	Stores historical temperature series (<code>15m</code> , <code>1h</code> , <code>3h</code> , <code>6h</code> , <code>12h</code> , <code>24h</code> views) and bridge ping RTT history

Component	Path / Address	Details
Dedicated Podman ULA IPv6	fd77:7777:5010:0:1337:f1ac:d00d:fb02 (Port 8000)	Bound on eth77 (10.0.0.3:8088 and 10.0.0.3:8000 mapped on IPv4 LAN for fireboardctl.drheck.dev)
DNS Configuration	~/git/router_config/unbound.conf & update_dns.py	Local Unbound (10.0.0.100 / fd77:7777:5010::1337:f1ac:d00d:aaaa) on danknasty + public deSEC IPv6 GUA sync
Nginx Site Config	/etc/nginx/sites-available/grill	Proxies / with Authentik ForwardAuth and /api/ingest with auth_request off
Backup & Restore Scripts	/home/luke/git/backups/u1/scripts/backup/grill, /home/luke/git/backups/u1/scripts/restore/grill	shellcheck -verified backups with par2 create -r10 parity archives in /data/backups/services/current/grill/

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