

CHANGELOG — v0.6.01 Robustness & Safety Upgrade

Date: February 17, 2026 **Author:** Justin Kwarteng **Status:** Hardware mod complete — circuit updated and verified

Summary

Implemented the hardware failsafe modification to the inverting low-side driver circuit. The key change moves the Q1 base pull-up from the ESP 3.3V rail to the 12V supply rail, ensuring the load stays **OFF** if the ESP32 loses power or crashes.

Circuit Changes (Old → New)

Component Changes

Component	Old Value	New Value	Reason
R1 (Q1 base pull-up)	10kΩ to 3.3V	100kΩ to 12V	Failsafe: keeps Q1 ON (load OFF) when 3.3V is lost
R2 (Q1 base series)	1kΩ	4.7kΩ	Reduces unnecessary GPIO/base current; Q1 only needs to sink ~0.24mA from 51k gate pull-up
R3 (MOSFET gate pull-down)	51kΩ	51kΩ (unchanged)	Already correct for gate discharge
Q1 (BJT inverter)	VN2222L	VN2222L (unchanged)	—
Q2 (MOSFET load switch)	MTA30N06E	MTA30N06E (unchanged)	—

Behavior Change

Scenario	Old Circuit	New Circuit
ESP GPIO HIGH (duty=0%)	Q1 ON → MOSFET OFF → Load OFF <input checked="" type="checkbox"/>	Same <input checked="" type="checkbox"/>
ESP GPIO LOW (duty>0%)	Q1 OFF → MOSFET ON → Load ON <input checked="" type="checkbox"/>	Same <input checked="" type="checkbox"/>
ESP 3.3V lost / unpowered	Q1 OFF (no pull-up) → MOSFET ON → Load ON ⚠ DANGEROUS	Q1 ON (12V pull-up still active) → MOSFET OFF → Load OFF <input checked="" type="checkbox"/> SAFE

Safety Analysis (12V Pull-Up Path)

- Path: **12V** → R1 (100kΩ) → Q1 Base → R2 (4.7kΩ) → ESP GPIO

- Total resistance: $\sim 104.7\text{k}\Omega$
 - Max current into GPIO when ESP is unpowered: $12\text{V} / 104.7\text{k}\Omega \approx 0.11\text{mA}$
 - ESP32 internal protection diodes safely handle $<1\text{mA}$ steady current
 - **No risk to ESP32 GPIO**
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Diagrams

File	Description
Old-circuit-diagram.jpeg	Hand-drawn original circuit (Feb 15) — 3.3V pull-up, 1kΩ/10kΩ resistors
Circuit-Diagram.drawio	Updated draw.io schematic — 12V failsafe pull-up, 4.7kΩ/100kΩ resistors
Circuit-Diagram.png	PNG export of the updated schematic

Verification Performed

1. Disconnected ESP 3.3V — confirmed MOSFET gate stays near 0V (load OFF)
 2. Normal operation — PWM duty control works identically to before
 3. Confirmed no direct 3.3V pull-up remains at Q1 base (old 10kΩ path removed)
 4. All grounds verified common (12V supply, ESP, INA260, load return)
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What Did NOT Change

- INA260 sensor wiring (I2C on GPIO6/GPIO7, powered from ESP 3.3V)
- MOSFET (Q2 MTA30N06E) and gate pull-down (R3 51kΩ)
- Load wiring (high-side through INA260 Vin+/Vin-)
- ESP32-C6 pin assignments (GPIO5=PWM, GPIO6=SDA, GPIO7=SCL)
- Any firmware or software — this was purely a hardware change