UNIVERSAL IoT BOARD v0.1

ESP32-S3 motherboard · optional MODEM / mikroBUS slots · DC, battery and solar through one charger

POWER

Power input

DC 5–24 V jack/terminal, USB bench power,

solar input, BQ25798 charger (MPPT,

dual input, NVDC), 1S Li-ion battery

File: power_in.kicad_sch

Power rails

3V3 TPS63802 (always on)

4× TPS22918 switched 3V3 rails

VMODEM switch, 5 V and 12 V boosts

File: power_rails.kicad_sch

CORE

MCU

ESP32-S3-WROOM-1-N16R8

USB-C + ESD, reset/boot, straps

TPL5010 external watchdog

File: mcu.kicad_sch

IO

I2C0: 2× TCA9535 expanders, RV-3032 RTC,

MAX17048 fuel gauge, ADS1115 ADC,

SC16IS752 dual UART · microSD

File: io.kicad_sch

I/O & EXPANSION

RS485

Isolated supply (B0505S), ISO7721,

THVD1426 auto-direction transceiver,

SM712 TVS, 120 Ω jumper, 2 terminals

File: rs485.kicad_sch

Slots

MODEM 2x10 slot (4G card + ID straps)

SLOT A / SLOT B mikroBUS sockets

bulk capacitance for 2 A bursts

File: slots.kicad_sch

Sensor ports

2× Qwiic I2C, UART, 1-Wire

2× analog (0–3.3 V / 0–10 V / 4–20 mA)

2× pulse inputs, 4× MOSFET outputs

File: ports.kicad_sch

VSYS (charger) → 3V3 always on. 3V3_SENS, 3V3_SD, 3V3_A, 3V3_B, 5V_SW, 12V_SW, VMODEM and ISO_5V

are switched from expander #1 and are OFF at boot. The isolated RS485 side uses ISO_5V / ISO_GND.

'calc' = computed from datasheet equations. 'TBD' / 'UNVERIFIED' / 'DNP' notes need a check before layout.

Generated by hardware/tools/gen_schematic.py — see hardware/README.md.

Universal IoT board — see docs/spec-v0.1.md

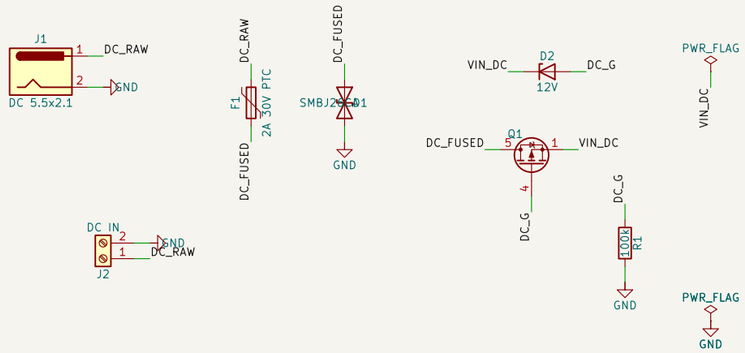
Sheet: /
File: iot-board.kicad_sch

Title: Universal IoT Board v0.1 — block diagram

Size: A3	Date: 2026-10-15	**Rev: 0.1**
KiCad E.D.A. 10.0.8		Id: 1/8

DC INPUT 5-24 V

Barrel jack or terminal · PTC · TVS · reverse-polarity P-FET (AO4485)



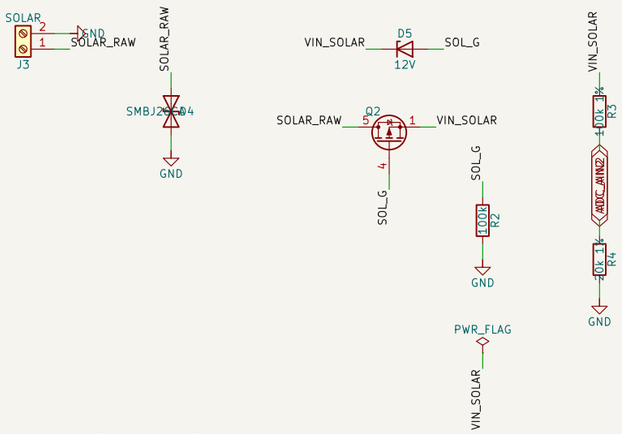
USB BENCH POWER

VUSB → VIN_DC through a 40 V Schottky (blocks 24 V back-feed)



SOLAR INPUT

6 V or 12 V panel, Voc ≤ 22 V · reverse-polarity P-FET (AO4485) · sense

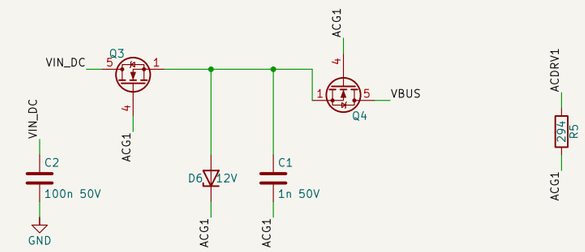


ADC_AIN2 = VIN_SOLAR / 6 (22 V → 3.67 V).

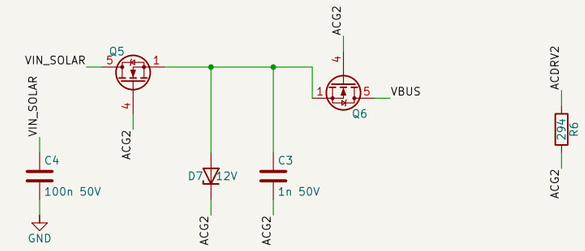
INPUT SELECTION

Back-to-back N-FET pairs on ACDRV1 / ACDRV2

VAC1 = VIN_DC



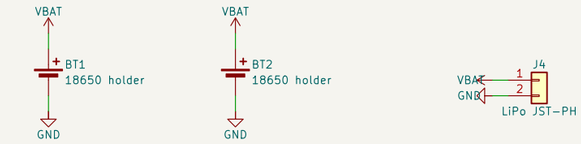
VAC2 = VIN_SOLAR



Q3–Q6 AON7410: 30 V, ±20 V V_GS, ≤ 26 mΩ at 4.5 V (ACDRV drives V_GS ≈ 5 V).

BATTERY

1S Li-ion: 2× 18650 in parallel or a LiPo on JST-PH



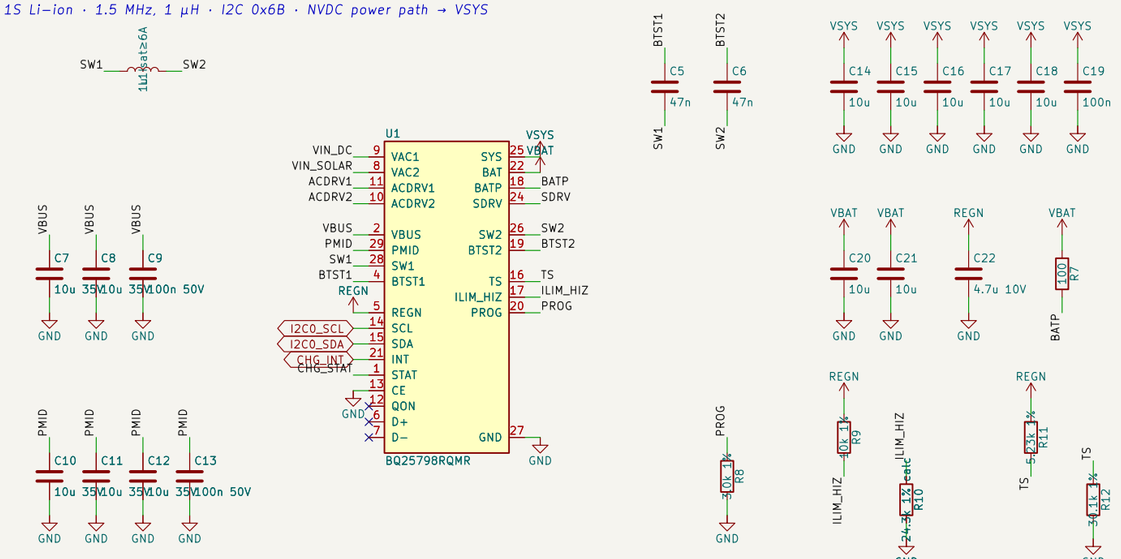


Use protected cells (PCM). Put the NTC next to the cells.

Fit either the holders or the LiPo, not both.

CHARGER — BQ25798

1S Li-ion · 1.5 MHz, 1 µH · I2C 0x6B · NVDC power path → VSYS



CHARGER NOTES

PROG 3.0k = 1S, 1.5 MHz (needs 1 µH).

ILIM_HIZ ≈ 3.4 V → 3 A input limit (calc).

TS 5.23k/30.1k + 103AT = JEITA 0–60 °C. CE low: EN_CHG bit.

D+/D− unused. Firmware: VAC_OVP 26 V, AUTO_INDET off.

Universal IoT board — see docs/spec-v0.1.md

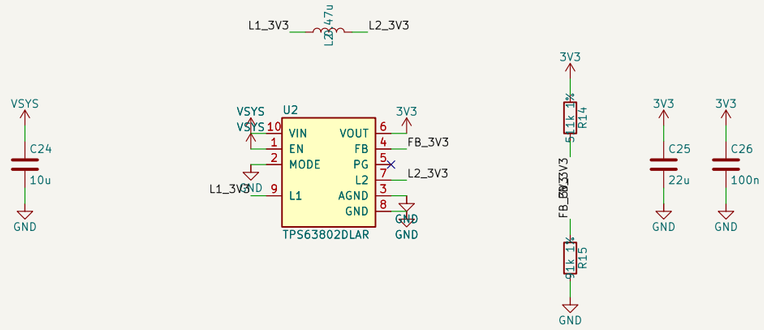
Sheet: /Power input/
File: power_in.kicad_sch

Title: Power input & charger: DC 5–24 V, solar, USB, BQ25798, battery

Size: A3	Date: 2026-10-15	**Rev: 0.1**
KiCad E.D.A. 10.0.8		Id: 2/8

3V3 MAIN — TPS63802

Buck-boost from VSYS · always on · 11 µA Iq · 2 A

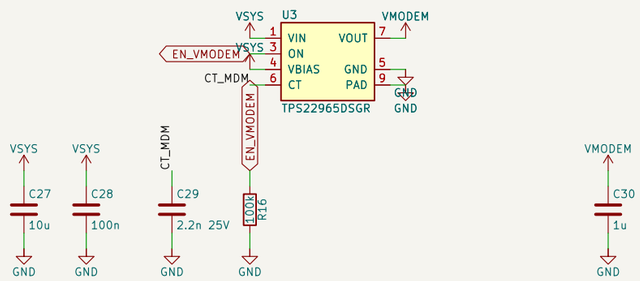


VOUT = 0.5 V × (1 + 511k/91k) = 3.31 V.

MODE low = power-save. PG unused.

MODEM SUPPLY — TPS22965

VSYS → VMODEM · 6 A switch, 2 A bursts

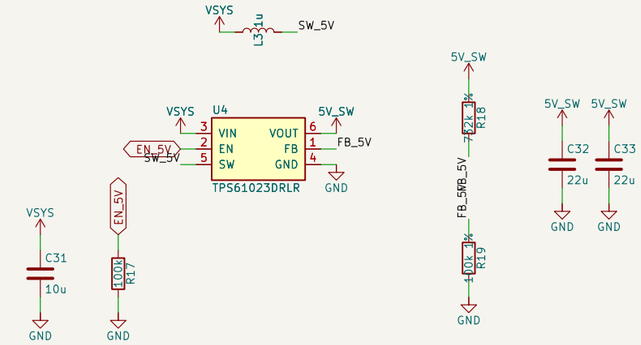


Bulk 470 µF + 100 µF sits at the MODEM header.

VBIAS = VSYS (≥ VIN).

5 V BOOST — TPS61023

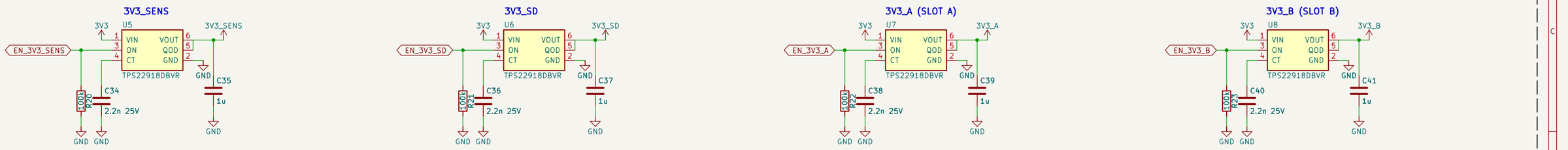
VSYS → 5V_SW · true disconnect when off



VOUT = 0.595 V × (1 + 732k/100k) = 4.95 V.

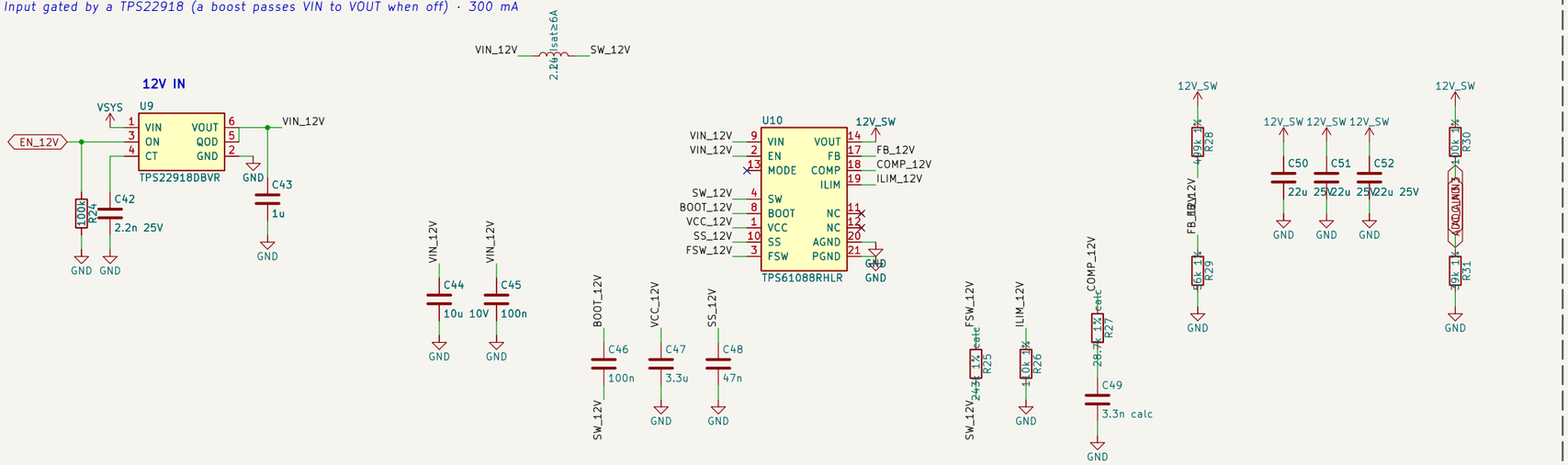
SWITCHED 3V3 RAILS

TPS22918 ×4 · OFF at boot (EN pulled down) · enabled by expander #1 · QOD on VOUT (C_L ≤ 200 µF) · CT 2.2 nF ≈ 3.6 ms rise



12 V BOOST — TPS61088

Input gated by a TPS22918 (a boost passes VIN to VOUT when off) · 300 mA



12 V NOTES

VOUT = 1.204 V × (1 + 499k/56k) ≈ 11.93 V

f_SW ≈ 600 kHz (calc)

ILIM = 550k / 110k = 5 A (PFM)

COMP values calc: verify the loop

on the first prototype

ADC_AIN3 = 12V_SW × 0.28

Universal IoT board — see docs/spec-v0.1.md

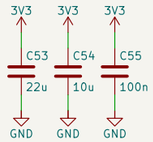
Sheet: /Power rails/
File: power_rails.kicad_sch

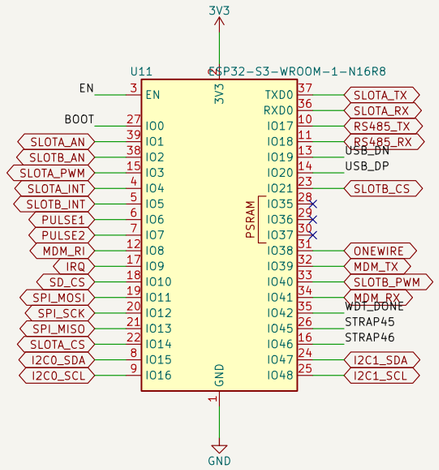
Title: Power rails: 3V3 buck-boost, load switches, modem switch, 5 V and 12

Size: A3	Date: 2026-10-15	**Rev: 0.1**
KiCad E.D.A. 10.0.8		Id: 3/8

ESP32-S3 MODULE

ESP32-S3-WROOM-1-N16R8 · GPIO map per docs/spec-v0.1.md



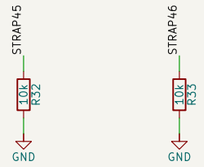


IO35–IO37 drive the octal PSRAM inside the module: leave unconnected.

TXD0/RXD0 (IO43/44) belong to SLOT A; the console runs on native USB (IO19/20).

STRAPPING PINS

IO45 low = 3.3 V flash · IO46 low for download



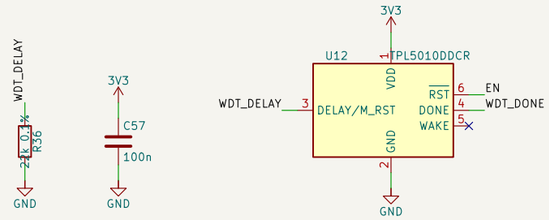
RESET & BOOT

EN RC delay · BOOT button on IO0



EXTERNAL WATCHDOG

TPL5010 · ~60 s · pulls EN low if WDT_DONE is not pulsed

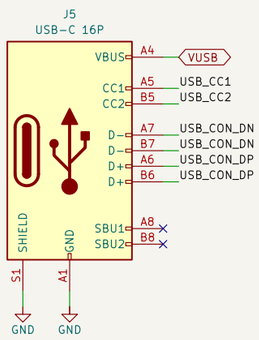


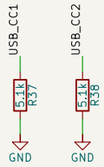
22 kΩ → t_IP ≈ 60 s (TPL5010 table). RSTn is open-drain into the EN RC (10k pull-up).

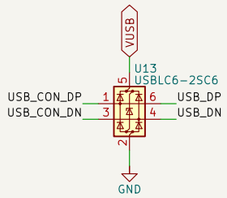
Firmware must pulse WDT_DONE (IO42) at least once per period.

USB-C

Flashing, debug console, bench power (VUSB → VIN_DC via Schottky)







USBLC6: route D+ through pins 1→6 and D− through 3→4 (flow-through).

CC1/CC2 5.1k to GND: the board is a USB sink.

Universal IoT board — see docs/spec-v0.1.md

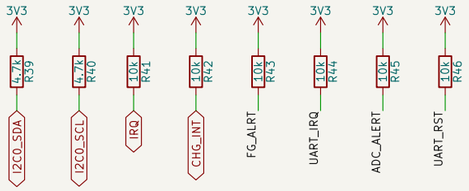
Sheet: /MCU/
File: mcu.kicad_sch

Title: MCU: ESP32-S3 module, USB-C, reset/boot, straps, watchdog

Size: A3	Date: 2026-10-15	**Rev: 0.1**
KiCad E.D.A. 10.0.8		Id: 4/8

I2C0 BUS & IRQ

Internal bus · open-drain pull-ups to 3V3



IRQ (IO9) = wired-OR of RTC INT,

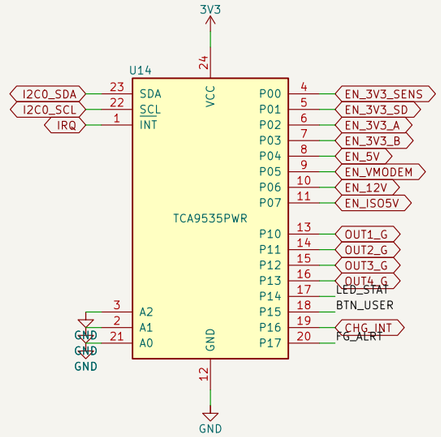
expander #1 INT and expander #2 INT.

0x20/0x21 TCA9535 · 0x36 MAX17048 · 0x48 ADS1115

0x4D SC16IS752 · 0x51 RV-3032 · 0x6B BQ25798

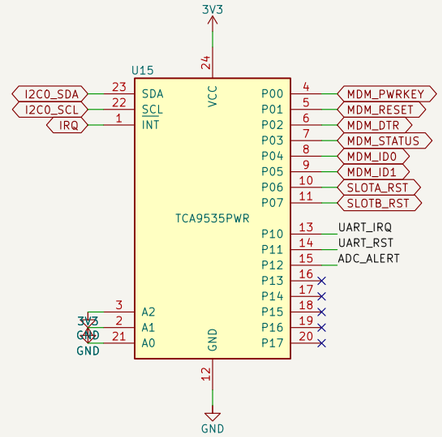
EXPANDER #1 — 0x20

TCA9535PWR (no internal pull-ups) · rails & outputs



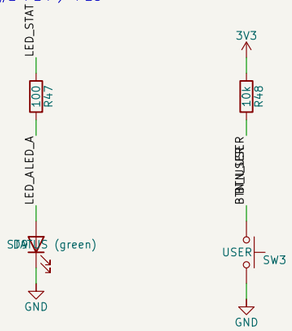
EXPANDER #2 — 0x21

TCA9535PWR · modem & slot control



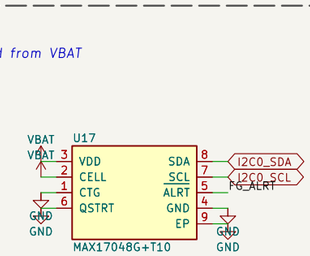
STATUS LED & USER BUTTON

Expander #1 P14 / P15



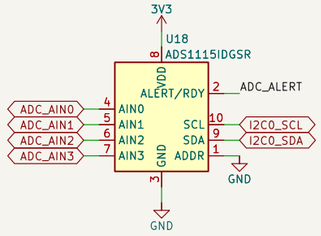
FUEL GAUGE — MAX17048

ModelGauge (Li-ion) · I2C 0x36 · powered from VBAT



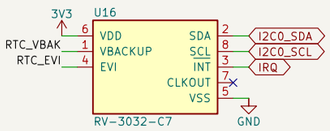
ADC — ADS1115

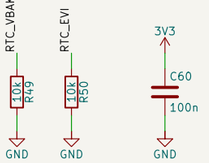
16-bit · I2C 0x48 · AIN0/1 ports · AIN2 solar · AIN3 12 V



RTC — RV-3032-C7

±2.5 ppm TCXO · 160 nA · I2C 0x51 · INT → IRQ



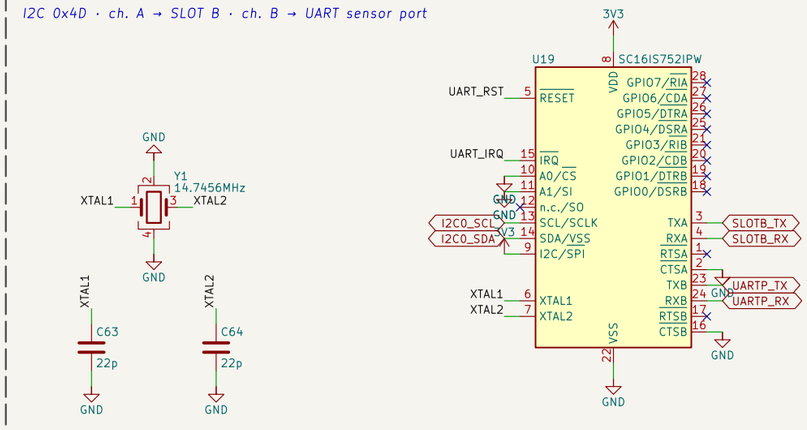


App Manual 8.1: VBACKUP, EVI to VSS via 10k.

Firmware: disable CLKOUT (NCLKE=1, CLKF=0).

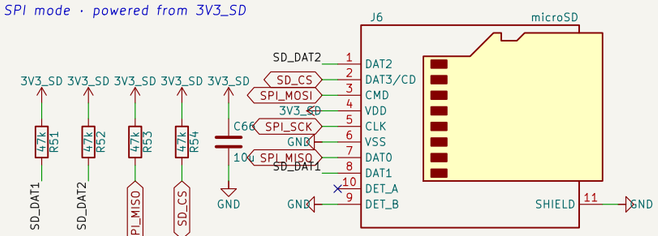
UART EXPANDER — SC16IS752

I2C 0x4D · ch. A → SLOT B · ch. B → UART sensor port



microSD

SPI mode · powered from 3V3_SD



Universal IoT board — see docs/spec-v0.1.md

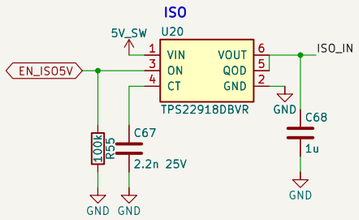
Sheet: /IO/
File: io.kicad_sch

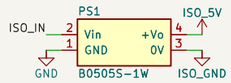
Title: I/O: I2C0 bus, expanders, RTC, fuel gauge, ADC, UART expander, micro

Size: A3	Date: 2026-10-15	**Rev: 0.1**
KiCad E.D.A. 10.0.8		Id: 5/8

ISOLATED SUPPLY

5V_SW → TPS22918 → B0505S-1W (1.5 kVDC) → ISO_5V / ISO_GND







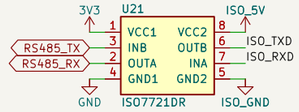


B0505S-1W (EVISUN): Cin = Cout = 10 µF per datasheet, ≤ 100 µF load.

Quiescent current 23 mA typ.: keep EN_ISO5V low in sleep.

ISOLATOR — ISO7721

1 forward (TX) + 1 reverse (RX) · default output high







TRANSCEIVER — THVD1426

Automatic direction control (from D) · 12 Mbps · 1/8 unit load



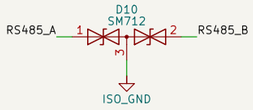


RE and SHDN high: receiver on except while transmitting (auto-direction).

10 Ω pulse-proof resistors per TI surge example (fig. 9-5).

BUS PROTECTION & TERMINATION

SM712 TVS · 120 Ω termination on a solder jumper

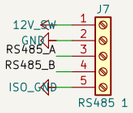


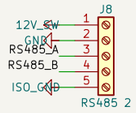


Close TERM only on the node at the end of the cable.

RS485 TERMINALS ×2 (DAISY CHAIN)

12V_SW + GND power the sensors · A / B / ISO_GND are the isolated bus





Pin order: 1 12V · 2 GND · 3 A · 4 B · 5 ISO_GND.

Sensors powered from 12V_SW share the board GND, so isolation then only protects against ground loops from separately powered devices.

Universal IoT board — see docs/spec-v0.1.md

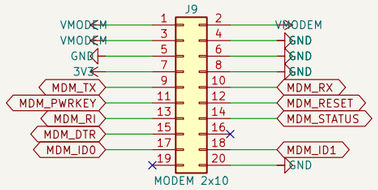
Sheet: /RS485/
File: rs485.kicad_sch

Title: Isolated RS485: isolated supply, ISO7721, THVD1426, protection

Size: A3	Date: 2026-10-15	**Rev: 0.1**
KiCad E.D.A. 10.0.8		Id: 6/8

MODEM SLOT

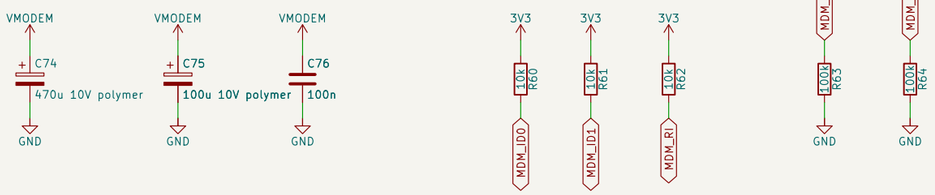
2x10 header, 2.54 mm · A7670E / SIM7600G-H / EG915U card · 3.3 V logic



Pin 9 MDM_TX = ESP32 → modem (IO39) · pin 10 MDM_RX = modem → ESP32 (IO41).

Pin 7: 3V3 reference for the card's 1.8 V level shifter (max 50 mA).

Card ID (ID1,ID0): 11 none · 10 A7670E · 01 SIM7600G-H · 00 EG915U/EC25.

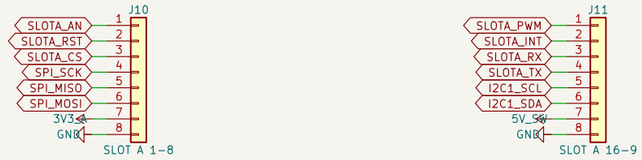


PWRKEY/RESET pull-downs: expander pins float until configured at boot.

Slot cards must not drive any pin at boot except through ≥10 kΩ (IO3 is a strapping pin).

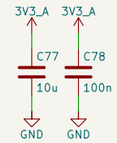
SLOT A — mikroBUS

UART0 (IO43/44) · SPI · I2C1 · rail 3V3_A



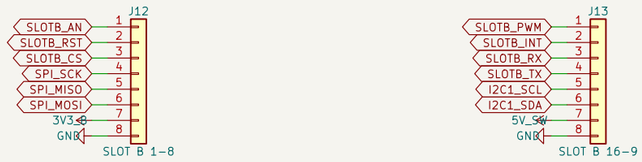
Left: 1 AN · 2 RST · 3 CS · 4 SCK · 5 MISO · 6 MOSI · 7 +3V3 · 8 GND

Right: 16 PWM · 15 INT · 14 RX · 13 TX · 12 SCL · 11 SDA · 10 +5V · 9 GND



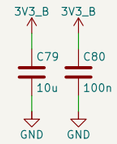
SLOT B — mikroBUS

UART via SC16IS752 ch. A · SPI · I2C1 · rail 3V3_B



Left: 1 AN · 2 RST · 3 CS · 4 SCK · 5 MISO · 6 MOSI · 7 +3V3 · 8 GND

Right: 16 PWM · 15 INT · 14 RX · 13 TX · 12 SCL · 11 SDA · 10 +5V · 9 GND



Universal IoT board — see docs/spec-v0.1.md

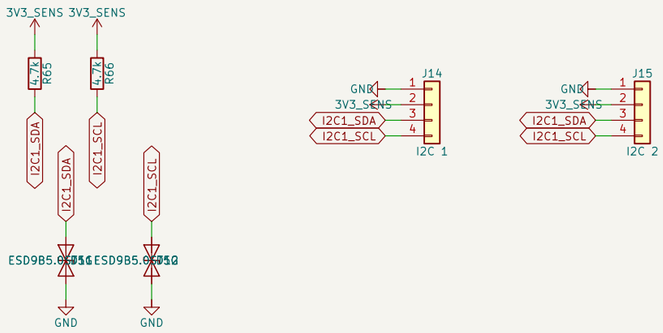
Sheet: /Slots/
File: slots.kicad_sch

Title: Expansion slots: MODEM (2x10) and two mikroBUS sockets

Size: A3	Date: 2026-10-15	**Rev: 0.1**
KiCad E.D.A. 10.0.8		Id: 7/8

I2C PORTS ×2 (QWIIC)

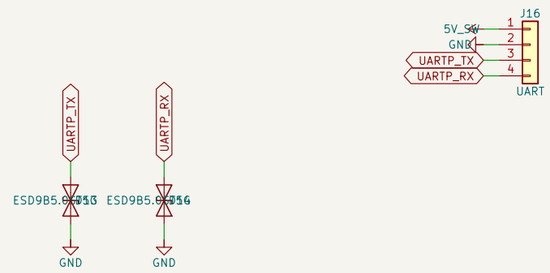
JST-SH 4P · I2C1 · 3V3_SENS



Pull-ups on 3V3_SENS: I2C1 is usable only while that rail is on.

UART SENSOR PORT

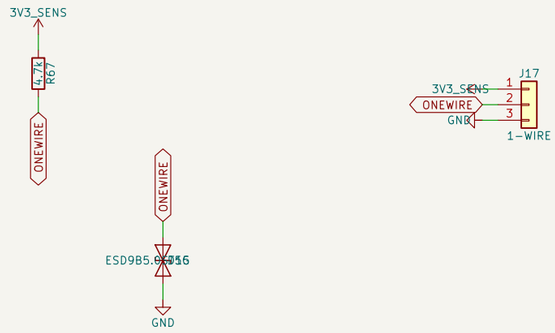
JST-XH 4P · SC16IS752 ch. B · 5 V supply, 3.3 V logic



Pin 3 = board TX (to sensor RX), pin 4 = board RX. e.g. PMS5003.

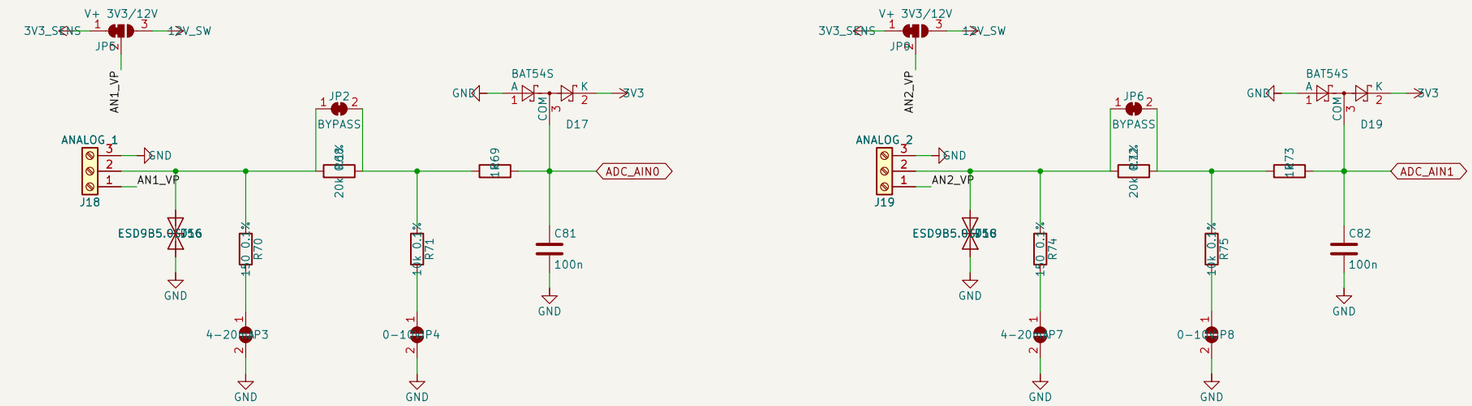
1-WIRE PORT

JST-XH 3P · DS18B20 chain · 4.7k pull-up



ANALOG INPUTS ×2

0–3.3 V · 0–10 V · 4–20 mA (solder jumpers) → ADS1115 AIN0 / AIN1

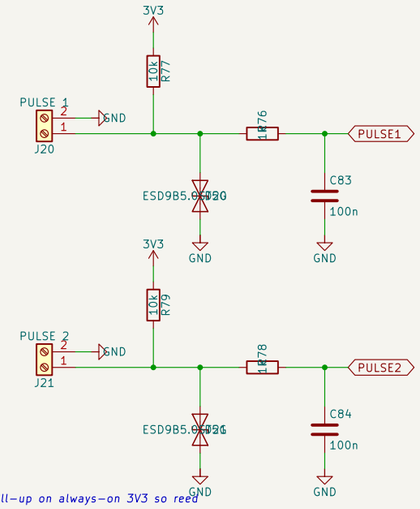


0–3.3 V: BYPASS closed (default). 0–10 V: cut BYPASS, close 0–10V (÷3).

4–20 mA: BYPASS + 4–20mA closed (20 mA × 150 Ω = 3.0 V). V+ jumper: 3V3_SENS (default) or 12V_SW.

PULSE INPUTS ×2

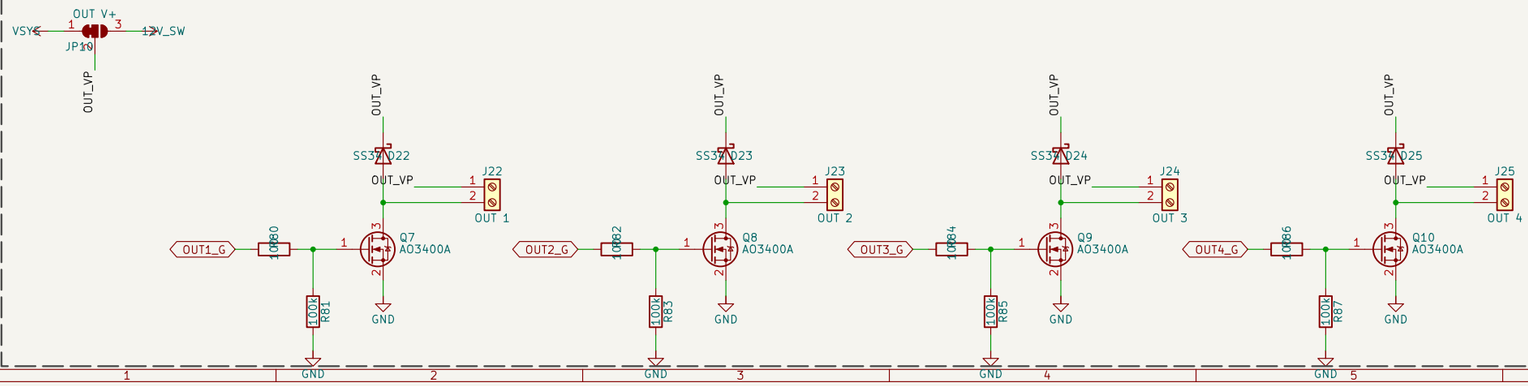
Rain gauge / anemometer · ULP counts in deep sleep



Pull-up on always-on 3V3 so reed contacts keep counting in deep sleep.

MOSFET OUTPUTS ×4

Low-side AO3400A · max 2 A each · V+ = VSYS or 12V_SW (solder jumper)



Universal IoT board — see docs/spec-v0.1.md

Sheet: /Sensor ports/
File: ports.kicad_sch

Title: Sensor ports: I2C, UART, 1-Wire, analog, pulse, outputs

Size: A3	Date: 2026-10-15	**Rev: 0.1**
KiCad E.D.A. 10.0.8		Id: 8/8