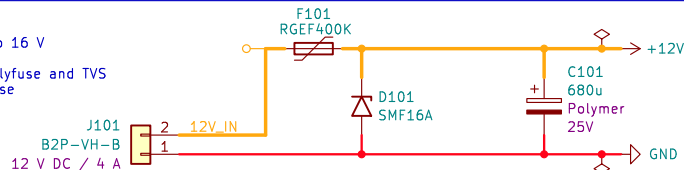


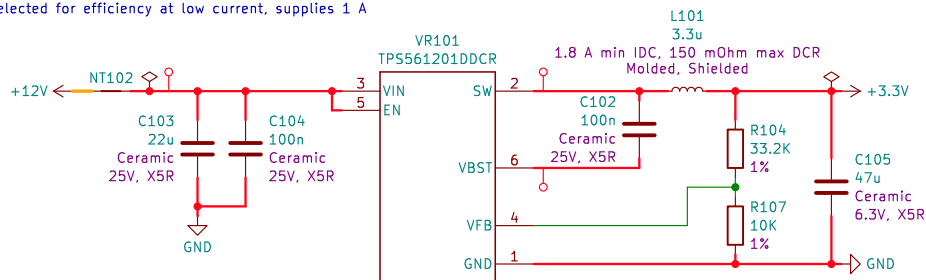
POWER INPUT

Input must be 9 to 16 V
Circuit protection
- Internal: 4 A polyfuse and TVS
- External: 5 A fuse

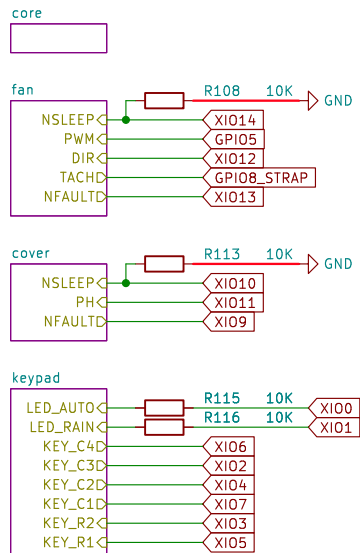


3.3 V BUCK CONVERTER

Selected for efficiency at low current, supplies 1 A

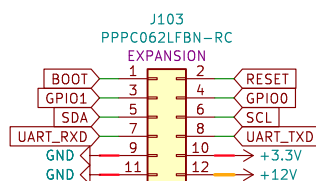


COMPONENTS



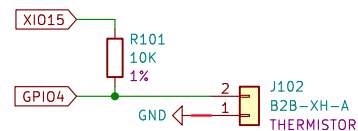
EXPANSION PORT

Header for accessories and factory programming
- GPIO0 and GPIO1 are free to be used for any purpose
- UART_RXD and UART_TXD provide the serial port
- SCL and SDA provide the I2C bus (QWIIC)
- RESET and BOOT are wired in parallel with their corresponding buttons (active when tied to ground)
- 12 V supply is unregulated, 1 A current available
- 3.3 V supply is regulated, 600 mA current available



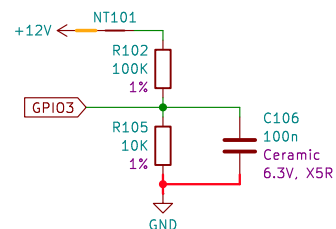
TEMPERATURE SENSOR

Built-in 10 K NTC thermistor, beta = 3950



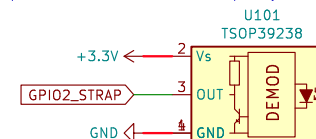
VOLTAGE SENSOR

Map to ESP32-C3 ADC range of 0 to 2.5 V



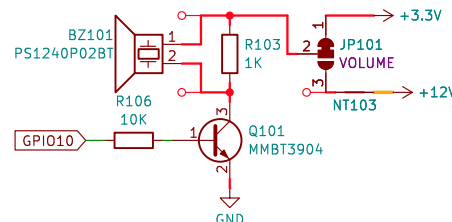
IR REMOTE RECEIVER

Operates on 38 kHz carrier frequency



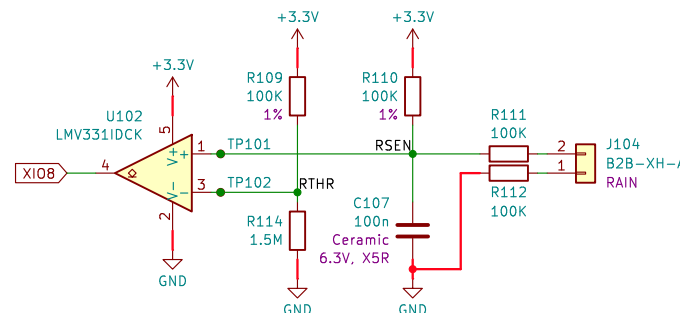
PIEZO BUZZER

Driven at 3.3 V for politeness (12 V will be louder)
Can be disabled in software or by cutting the solder jumper



RAIN SENSOR

The rain sensor is only available on model 4500K; these components may be omitted for other models
It is simply a pair of electrodes that are exposed to the environment and whose impedance is about 0.5 to 1.2 Mohm when in contact with water or mist and open circuit when dry
The comparator pulls the output low when $V(RSEN) < V(RTHR) + V(OFFSET)$, where $V(OFFSET)$ is ± 5 mV for LMV331X



Brown Studios LLC

Sheet: /
File: minueta.kicad_sch

Title: Minuet Fan Controller

Size: A4 Date: 2025-02

KiCad E.D.A. 8.0.8

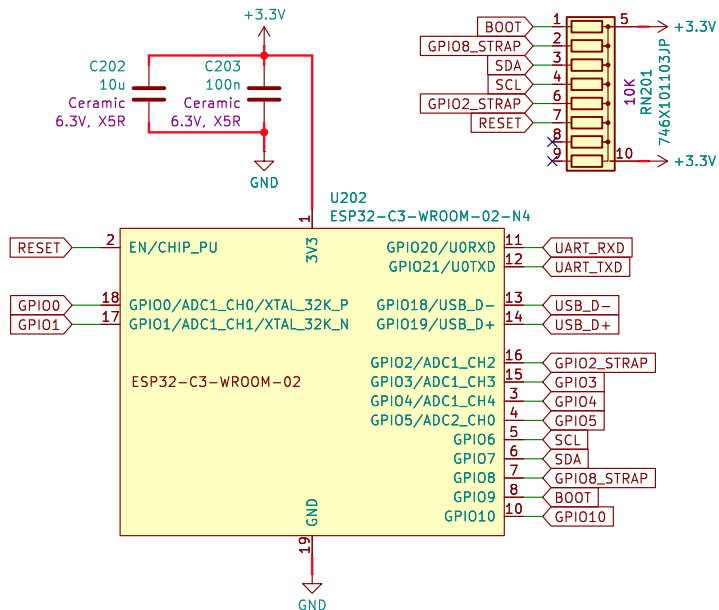
Rev: 2.1

Id: 1/5

MICROCONTROLLER

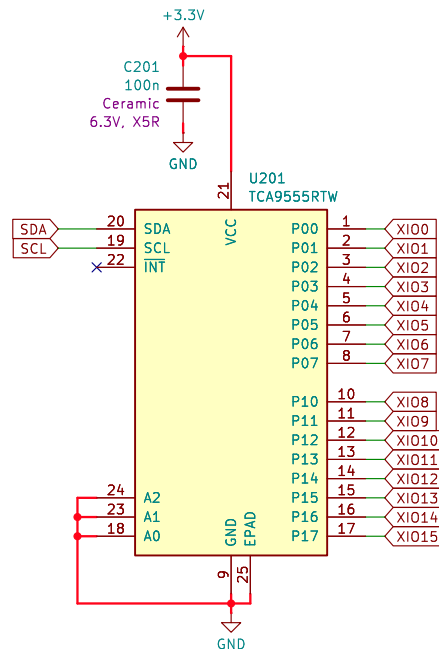
ESP32-C3 strapping pins

- GPIO2 don't care but recommended to pull up anyway to avoid glitches
- GPIO8 must be high for download mode, don't care for SPI mode
- GPIO9 boot select: low for download mode, high for SPI mode
- RESET forms an RC delay circuit with $R = 10\text{ Kohm}$, $C = 1\text{ uF}$ to ensure power supply stability



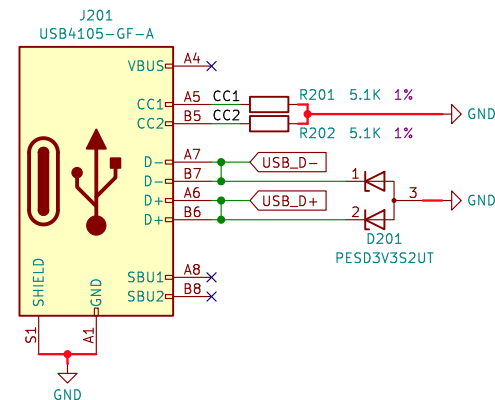
IO EXPANDER

XIO pins have internal 100 K pull-ups, configured as inputs at reset, cannot be set to Hi-Z, 50 mA push-pull output, 5 V tolerant



USB-C INTERFACE

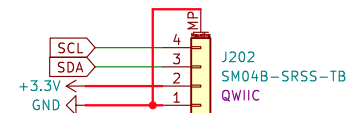
ESP32-C3 only supports full-speed data rate (11 Mbps)



QWIIIC INTERFACE

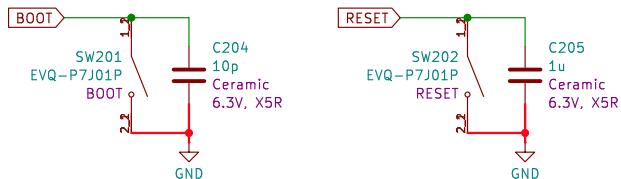
A great place to plug in off-the-shelf accessories

- Host has pull-ups so accessories don't need their own
- 3.3 V supply is regulated, 600 mA current available



BUTTONS

Hold BOOT, press/release RESET, then release BOOT to enter the bootloader for firmware updates



Sheet: /core/
File: core.kicad_sch

Title: Minuet Core

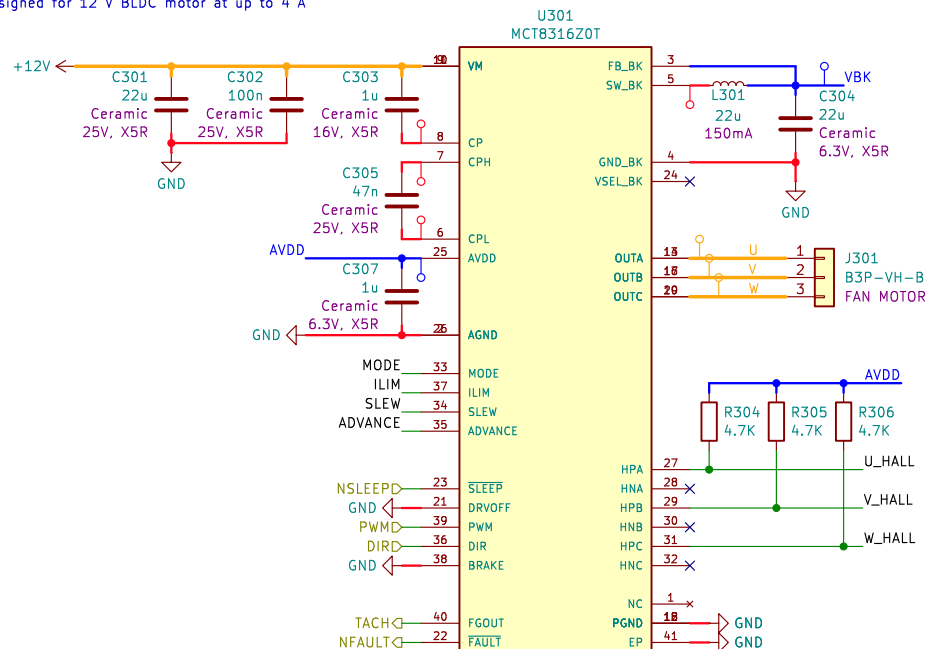
Size: A4
KiCad E.D.A. 8.0.8

Date:

Rev:
Id: 2/5

FAN MOTOR DRIVER

Designed for 12 V BLDC motor at up to 4 A

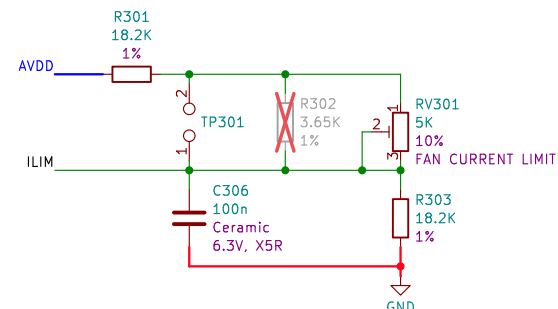


AVDD supplies 20 mA @ 3.3 V derived from VM when NSLEEP is active
SW_BK supplies 50 mA @ 5 V from a built-in buck converter
NFAULT is open-drain, must be high on reset to not enter test mode
TACH/FGOUT is open-drain, pulses with each hall sensor transition

Internal pull-down on NSLEEP, BRAKE, DIR, PWM, DRVOFF

CURRENT LIMIT

Increasing resistance of the setpoint increases the current limit
Specified to a maximum of 4 A

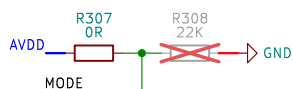


Current limit setting for sum of all phases
- Assume CSA_GAIN = 0.15 V/A, V(AVDD) = 3.3 V
- Calculate Ilim
$$I_{lim} = V(AVDD) * (0.5 - R_F / (2 * R_F + R_V)) / CSA_GAIN * 3$$
$$I_{lim} = 66 \text{ A} * (0.5 - R_F / (2 * R_F + R_V))$$

- Choose R_F so that Ilim_max = 4 A with RV_max = 5 K
R_F = 18.2 Kohm
- Calculate R_V for given Ilim
$$R_V = R_F * (1 / (0.5 - I_{lim} / 66 \text{ A}) - 2)$$

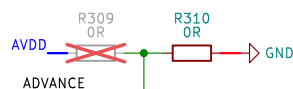
Approximate setpoints rounded to nearest E96 series value
- Ilim = 0 A (disabled) => R_V = 0 K
- Ilim = 1 A => R_V = 1.13 K
- Ilim = 1.5 A => R_V = 1.74 K
- Ilim = 2 A => R_V = 2.32 K
- Ilim = 2.5 A => R_V = 3.00 K
- Ilim = 3 A => R_V = 3.65 K (default)
- Ilim = 3.5 A => R_V = 4.32 K
- Ilim = 4 A (maximum) => R_V = 4.99 K

COMMUTATION MODE



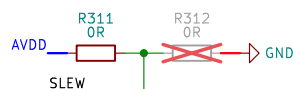
Mode
- Type 2: tied to AGND via 22 Kohm resistor
- digital hall input
- asynchronous modulation
- ASR & AAR disabled
- Type 4: Hi-Z
- digital hall input
- synchronous modulation
- ASR & AAR disabled
- Type 7: tied to AVDD (default)
- digital hall input
- synchronous modulation
- ASR & AAR enabled

COMMUTATION ADVANCE



Commutation advance lead angle
- 0°: tied to AGND (default)
- 4°: tied to AGND via 22 Kohm resistor
- 11°: tied to AGND via 100 Kohm resistor
- 15°: Hi-Z
- 20°: tied to AVDD via 100 Kohm resistor
- 25°: tied to AVDD via 22 Kohm resistor
- 30°: tied to AVDD

SLEW RATE



Slew rate control
- 25 V/uS: tied to AGND
- 50 V/uS: Hi-Z
- 100 V/uS: tied to AVDD via 47 Kohm resistor
- 200 V/uS: connected to AVDD (default)

Sheet: /fan/
File: fan.kicad_sch

Title: Minuet Fan Motor Driver

Size: A4

Date:

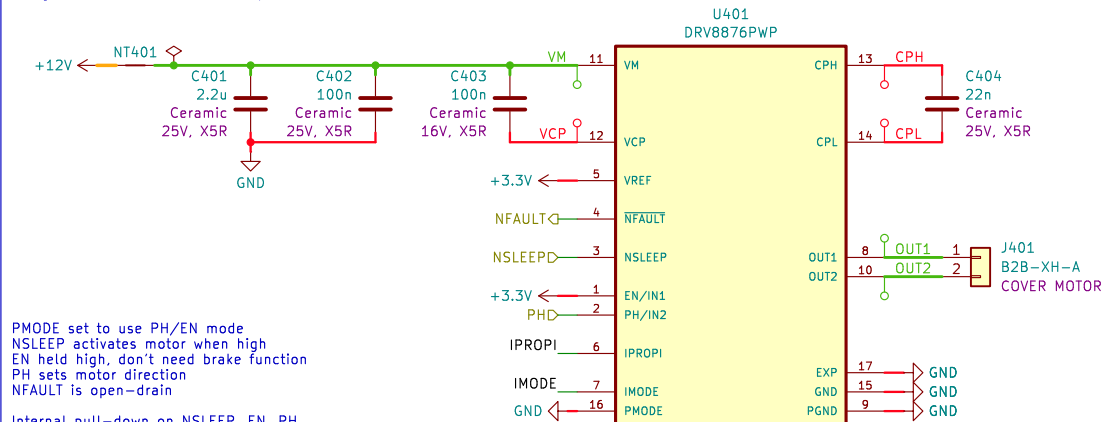
KiCad E.D.A. 8.0.8

Rev:

Id: 3/5

COVER MOTOR DRIVER

Designed for 12 V DC motor at up to 2 A

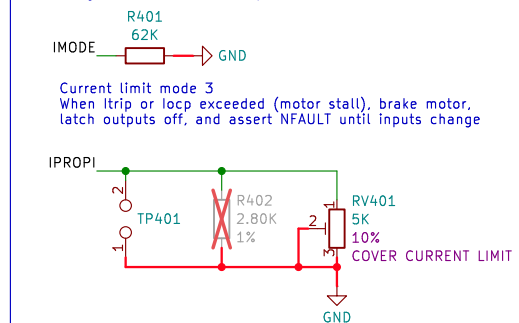


PMODE set to use PH/EN mode
NSLEEP activates motor when high
EN held high, don't need brake function
PH sets motor direction
NFAULT is open-drain

Internal pull-down on NSLEEP, EN, PH

CURRENT LIMIT

Increasing resistance of the setpoint decreases the current limit



Set overcurrent protection trip current
 $I_{trip} (A) = 1000 \cdot V_{ref} (V) / R_{ipropi} (\Omega)$
Given $V_{ref} = 3.3 V$, $R_{ipropi} = 2.8 K$, $I_{trip} = 1.18 A$

Must be set high enough to allow the motor to overcome the torque demands of the cover mechanism and low enough to reliably detect stall at end of travel.

Sheet: /cover/
File: cover.kicad_sch

Title: Minuet Cover Motor Driver

Size: A4

Date:

KiCad E.D.A. 8.0.8

Rev:

Id: 4/5

Compatible with original equipment

- R1+GND: Close cover
- R2+GND: Open cover
- R1+C1: Fan off
- R1+C2: Fan speed up
- R1+C3: Fan speed down
- R1+C2+C3: Open / close cover
- R1+C4: Toggle rain sensor (only certain models)
- R2+C1: Fan on and cycle speeds
- R2+C2: Fan on / off
- R2+C3: Fan intake / exhaust direction
- R2+C4: Toggle auto thermostat

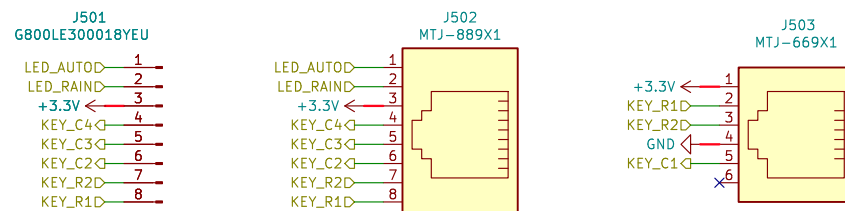
- R1+GND: Close cover
- R2+GND: Open cover
- R1+C1: Fan off
- R1+C2: Fan speed up
- R1+C3: Fan speed down
- R1+C2+C3: Open / close cover
- R1+C4: Toggle rain sensor (only certain models)
- R2+C1: Fan on and cycle speeds
- R2+C2: Fan on / off
- R2+C3: Fan intake / exhaust direction
- R2+C4: Toggle auto thermostat

- LED_AUTO: Auto LED cathode, green with 2.4 V voltage drop
- LED_RAIN: Rain LED cathode, red (only certain models)

- LED_AUTO: Auto LED cathode, green with 2.4 V voltage drop
- LED_RAIN: Rain LED cathode, red (only certain models)

KEY_Rx and KEY_Cx inputs need pull-ups
 Detect key press when KEY_Rx goes low when undriven (tristate)
 Detect key press when KEY_Cx goes low during high-to-low strobe of KEY_Rx
 Fan originally provided +5V supply the interface but +3.3V works fine

KEY_Rx and KEY_Cx inputs need pull-ups
 Detect key press when KEY_Rx goes low when undriven (tristate)
 Detect key press when KEY_Cx goes low during high-to-low strobe of KEY_Rx
 Fan originally provided +5V supply the interface but +3.3V works fine



Title: Minuet Keypad Interface

Date:

Rev:

Id: 5/5