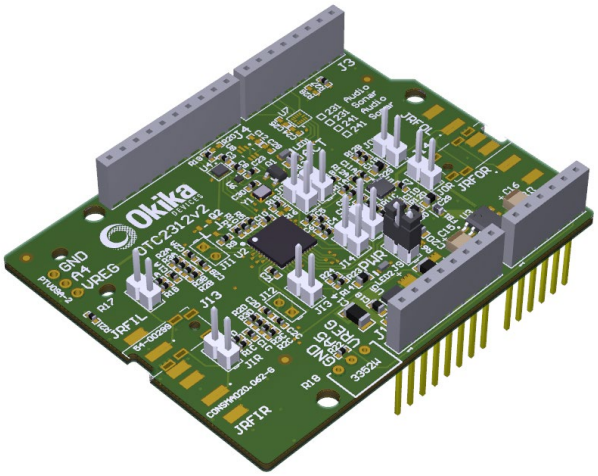
OTC2312 FlexAnalog™ FPAA Shield
Arduino Uno Form Factor

Features

- AN231E04 Field Programmable Analog Array
- Supports analog signals up to 400kHz (AN231) or 1.2MHz (AN241)
- Arduino Uno Shield Form Factor (stackable)
- Dual analog signal channel support
- 16 MHz on board oscillator
- Rauch Filter components for ground-referenced single-ended inputs
- Fully differential signal path on board
- Differential to single-ended output converters for compatibility with common bench test equipment
- On board 3.3V regulator
- On board -3.3V charge pump
- 5V to 3.3V level shifters for SPI programming interface
- Footprints for stereo input and output 3.5mm audio jacks
- Footprints for dual SMA inputs and outputs
- Footprints for two potentiometers
- Chip current monitoring header pins
- Component population options for SPI chip-select



Applications

Educational, hobbyist, and professional exploration of analog signal processing for:

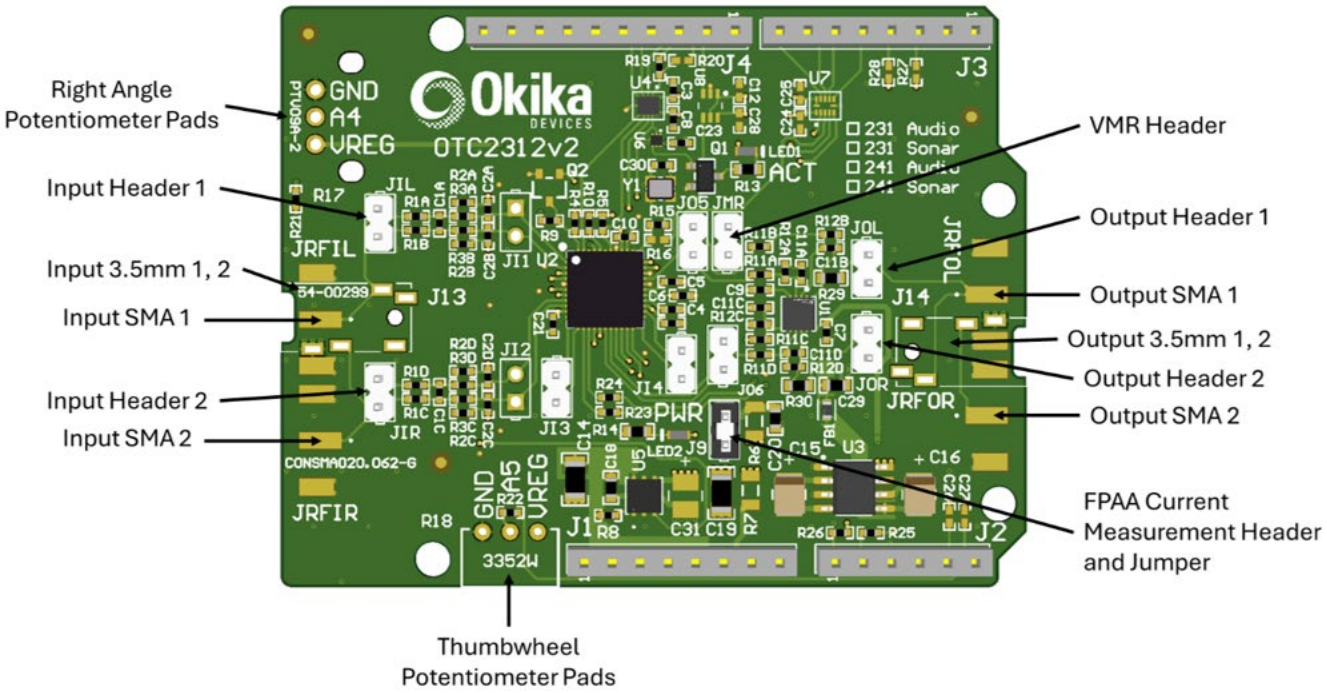
- Audio filtering and analog effects
- Sensor signal conditioning
- Ultrasonic (sonar) acoustic baseband processing
- Antialiasing filters for ADC inputs
- Industrial automation and process Control
- Biomedical instrumentation

Description

The OTC2312 Arduino Shield provides a convenient introduction to software programmable analog signal processing. Featuring the AN231E04 field-programmable analog array (FPAA) and an assortment of support circuits, the OTC2312 plugs into any Arduino Uno module and includes everything needed to process one or two signal channels. The shield can also be used with non-Arduino microcontroller boards such as ESP32, Raspberry Pi, and Beagle Board.

Circuits are constructed from a library of 43 configurable analog modules (CAMs) using Okika's Designer software. A differentiating feature of FlexAnalog™ FPAAs is the ability to simultaneously update every register in the configuration register map, thereby enabling circuits that evolve smoothly over time. This capability has been applied to implement time-varied gain (TVG) in sonar, LPF-controlled filters used in music synthesis, and post-mixer automatic gain control (AGC) for RFID readers.

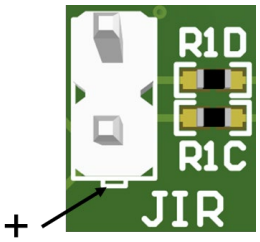
Board Connectors



The OTC2312 shares outline and mounting hole locations with the Arduino Uno and is intended to be mounted on top of the Arduino Uno. Connectors on the top side of the board allow other compatible shields to be stacked on top without requiring jumper wires. The board can also be used with other popular microcontroller modules and different Arduino form factors by running wires between the boards.

The drawing above shows the location of the board connectors. Three connector options are supported for the two analog inputs and outputs.

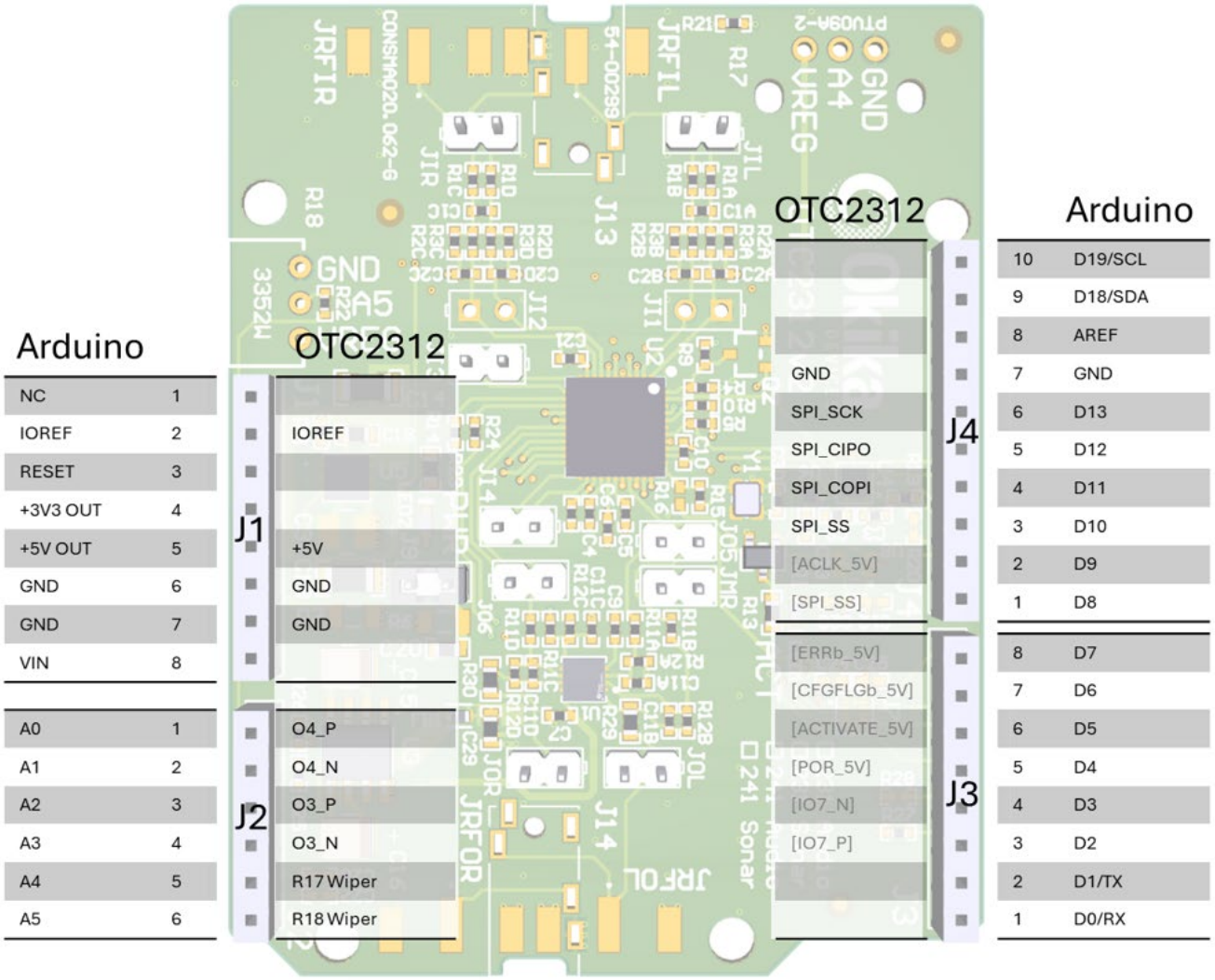
1. 0.1in (2.54mm) headers. Installed at factory. The + side of each header is indicated by a rectangular mark.



2. Female edge mount SMA connectors. Not installed. Use TE Connectivity CONSMA020.062-G or compatible receptacle.
3. Right angle stereo 3.5mm audio jack. Not installed. Use Tensility 54-00299.

The FPAA current measurement jumper (J9) must be installed for the board to run. The jumper may be removed from J9 and the two header pins routed through an ammeter to measure the current consumed by the FPAA.

Pin Functions

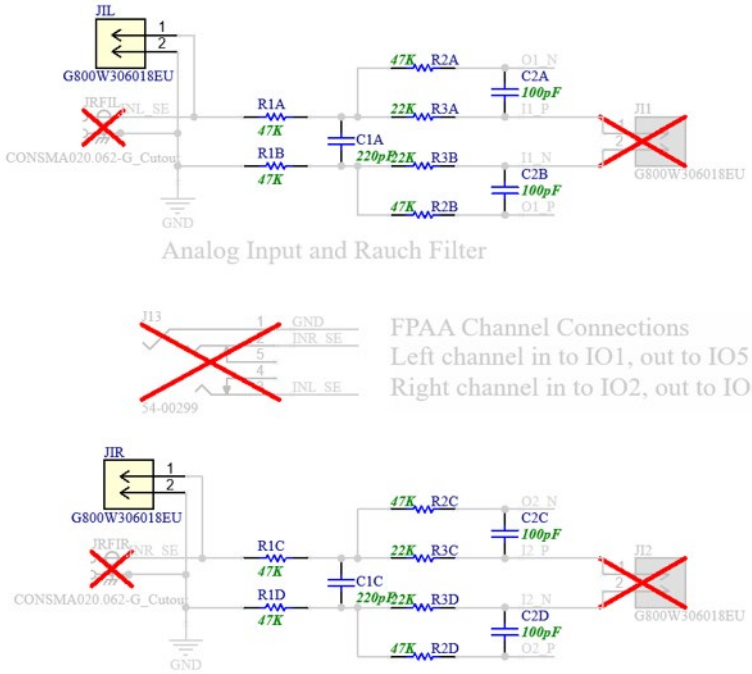


The image above shows the pins used by the OTC2312 FPAA shield. Additional FPAA signals, indicated by [gray] text may be accessed by populating additional level shifters and decoupling capacitors. These signals are not required for most applications and have been omitted to simplify software and reduce the risk of conflict when stacking with other shields. Refer to the Optional FPAA Digital to Arduino Connections section below for further details. When using the OTC2312 shield with non-Arduino microcontroller boards, the IOREF pin must be connected to a power supply voltage that matches the IO voltage of the module, typically either 3.3V or 5V.

Analog Inputs

The OTC2312 supports two ground-referenced single-ended inputs. Boards are shipped with headers installed at JIL and JIR for easy prototyping. Footprints are also provided for edge mounted SMA connectors (JRFIL, JRFIR) and a stereo 3.5mm audio jack (J13). Compatible part numbers are printed on the PCB and can be ordered from electronic component distributors such as Digikey.

The FPAA works with differential signals that are biased with a common mode voltage near VMR, which is typically 1.5V. The OTC2312 provides components that work in conjunction with the FPAA input amplifier to implement a Rauch filter that converts the single-ended input to properly biased differential signals. These components also implement a lowpass filter. The standard filter components produce a 23kHz corner frequency appropriate for audio signals. Different input gain and corner frequency can be achieved by changing the components as described below. If the analog signals are already differential signals centered around VMR, the Rauch components can be depopulated and the signal connected directly to JI1 or JI2.



Rauch Filter Calculations
f0 = 1 / (2 * pi * R2) * sqrt[(R1 + R2) / (2 * C2 * C1 * R1)]
f0 = 23 kHz (audio)
f0 = 488 kHz (HF)

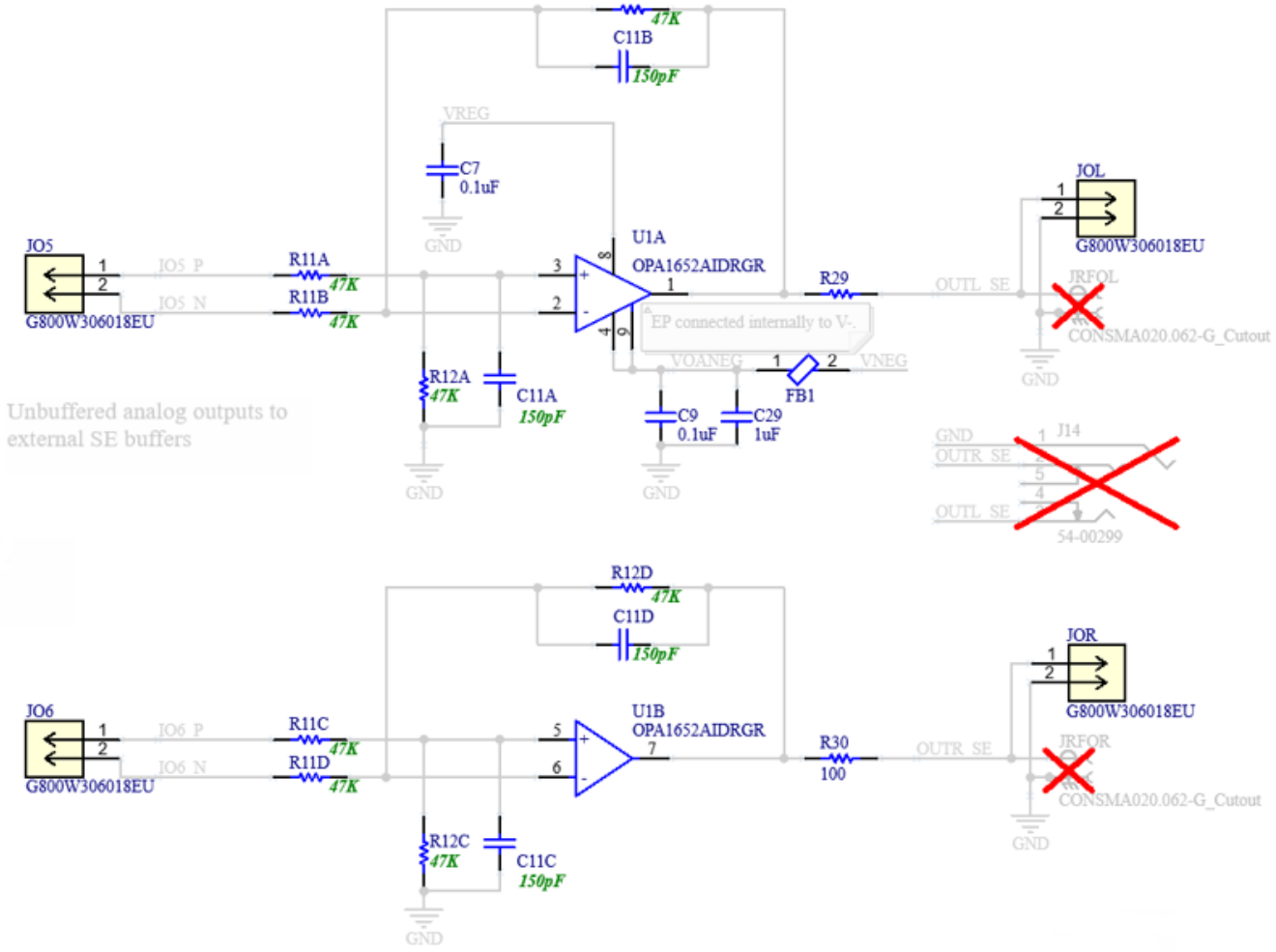
G = R2 / R1
G = 1, +/- 2.75V limit before distortion/clipping

Q = sqrt[(C1 * R1) / (2 * C2 * (R1 + R2))]
Q = 0.74 (audio)
Q = 0.74 (HF)

Comp	Audio	Sonar
R1x	47K	22K
R2x	47K	22K
R3x	22K	10K
C1x	220pF	22pF
C2x	100pF	10pF
f0	23 kHz	488kHz
G	1	1
Q	0.74	0.74

Analog Outputs

The OTC2312 provides two buffered analog outputs at JOL and JOR. The outputs are ground-referenced and single-ended, simplifying signal analysis using standard test equipment such as oscilloscopes and spectrum analyzers. Footprints for edge mounted SMA outputs are also provided (JRFOL, JRFOR) along with a stereo 3.5mm output jack (J14). The analog outputs are intended to drive high impedance loads (>100 ohms). Current limiting output resistors are included on boards starting with version 2. Unbuffered differential outputs can be accessed at JO5 and JO6.



G = R12 / R11

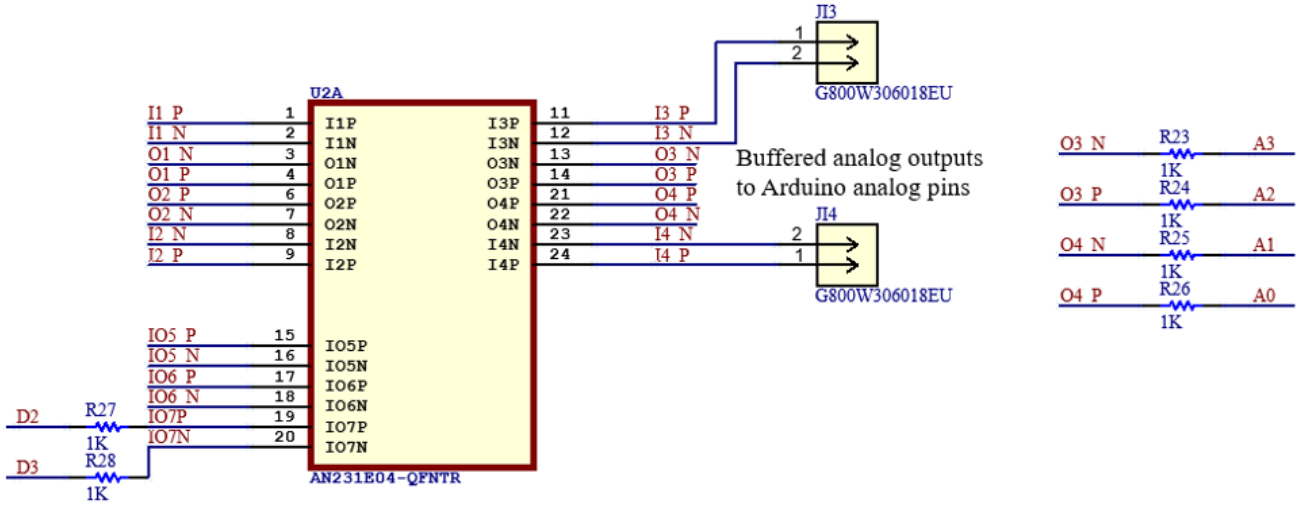
f0 = 1 / (2 * pi * R12 * C11)

Comp	Audio	Sonar
R11x	47K	22K
R12x	47K	22K
C11x	150pF	15pF
f0	23 kHz	480kHz
G	1	1

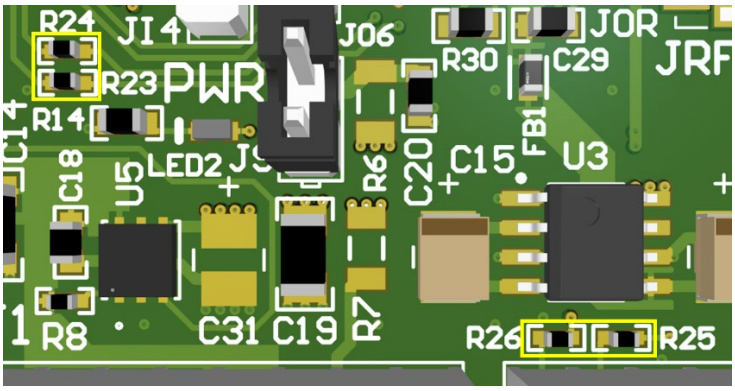
FPAA Analog to Arduino Connections

Four analog signal connections are made between the FPAA and Arduino. These connections enable the Arduino ADCs to digitize signals after processing by the FPAA. Outputs from IOCell3 are available on A2 and A3, and outputs from IOCell4 are available on A0 and A1. Starting with version 2, 1K series resistors are provided to prevent damage to the 3.3V FPAA if the Arduino signals A0 – A3 are driven or pulled up to 5V. When driving FPAA outputs to the Arduino, IOCell3 and IOCell4 can be configured as a sample & hold output to buffer the outputs.

The Arduino library does not support differential ADC inputs. Furthermore, the analog inputs of the Arduino are multiplexed so they are not simultaneously sampled. For signals that are much lower frequency than the ADC sample frequency, it is still reasonable to sample both P and N signals and calculate the difference. For higher frequency signals, however, the sequential sampling will make the P and N samples too far out of phase, so only one side should be used. Sampling only one side results in a 6dB reduction in signal, which can be accounted for in software.

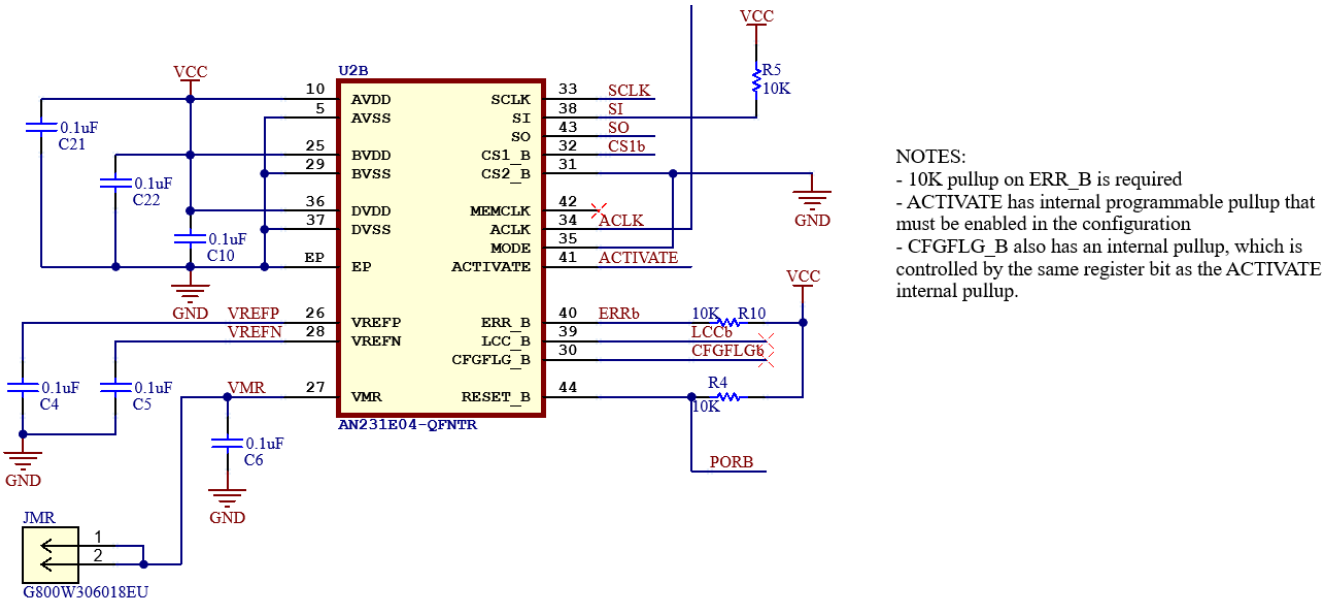


If FPAA analog to Arduino connections are not required, R23 – R26 can be removed (version 2 and later), freeing up those signals to be used by other shields in the stack.



FPAA Internal Connections

The OTC2312 board provides all pullups and decoupling capacitors required by the FPAA. The mid-rail voltage VMR of the FPAA is provided on header JMR and can be used to bias external circuits. The FPAA's VMR can also be disabled and VMR driven from external circuitry. Note, however, that forcing an external VMR will reduce the available voltage swing.



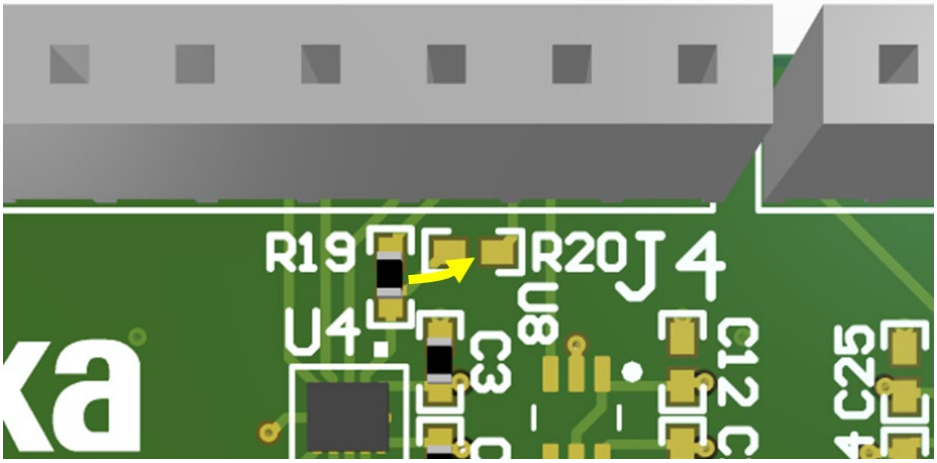
NOTES:
- 10K pullup on ERR_B is required
- ACTIVATE has internal programmable pullup that must be enabled in the configuration
- CFGFLG_B also has an internal pullup, which is controlled by the same register bit as the ACTIVATE internal pullup.

SPI Configuration Interface

The SPI interface is used to configure the FPAA. Level shifters are included on the board to convert between IOREF voltage (typically 5V) to the FPAA logic level of 3.3V. The SPI interface uses the following digital pins:

SPI Signal	Pin	Name	Notes
Select	D10	SPI_SS	Active low Move resistor from R19 to R20 to change SS to D8
Arduino data out FPAA data in	D11	SPI_COPI (MOSI)	
Arduino data in FPAA data out	D12	SPI_CIPO (MISO)	
Clock	D13	SCK	

By default, the SPI_SS pin is connected to D10 of the Arduino. Since other shields may also use D10 for SPI_SS, an option is provided to move SPI_SS to D8 by removing the 0 ohm resistor at R19 and soldering it at R20 as shown below.



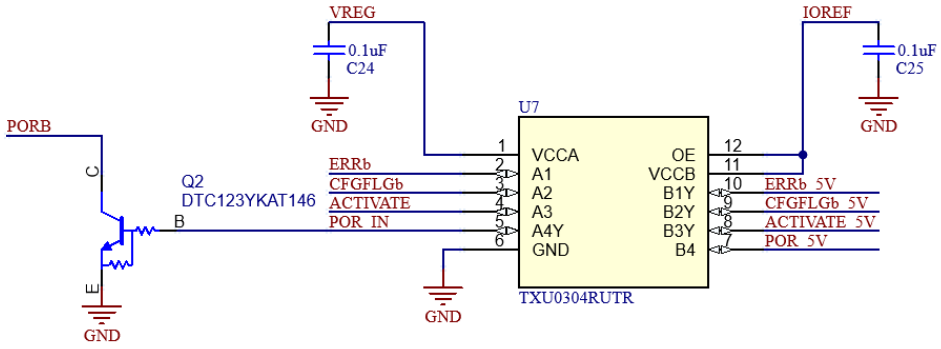
The OTC2312 supports either SPI mode 0 or mode 3. In both mode 0 and mode 3, input data is captured on the rising edge of the clock and outputs are driven on the falling edge of the clock. The SPI clock can be operated at frequencies up to 40MHz. Refer to the AN231 datasheet, user manual and application notes for further details on configuring the FPAA. At a high level, configuration involves exporting a sequency of bytes from the Designer software and transferring the byte stream over the SPI interface after power up or reset.

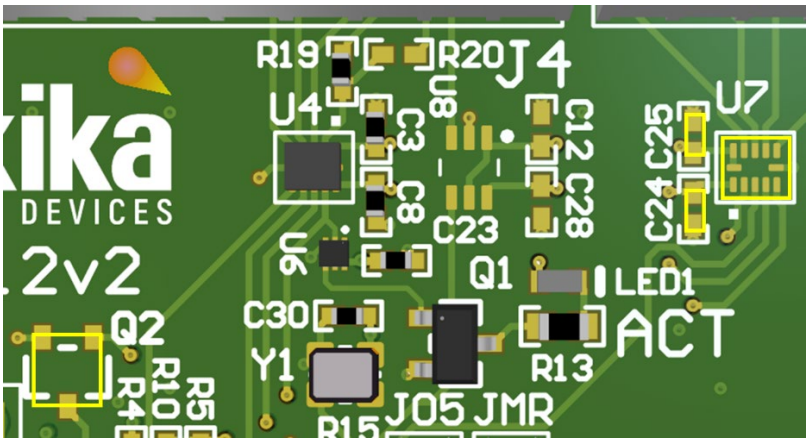
Reconfiguration of the FPAA can occur while the previous configuration is running and the full configuration transferred from the shadow RAM in the active RAM on the same clock cycle. The design software includes tools for algorithmic parameter updates (same circuits, different parameters) and state-driven configuration updates (new circuits).

Optional FPAA Digital to Arduino Connections

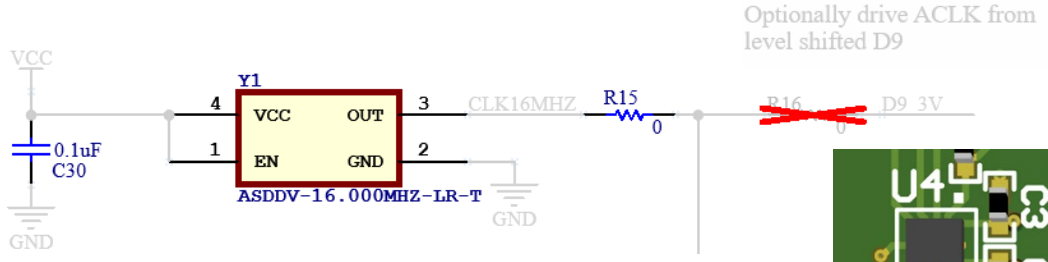
IO7P and IO7N can be connected to D2 and D3 of the Arduino by populating R27 and R28 on version 2 and later. These resistors are not populated by default because the 3.3V logic level the FPAA is not guaranteed to meet the VIH level for standard Arduinos with 5V IOREF voltage.

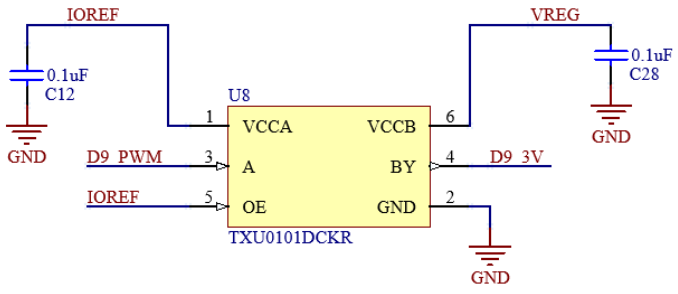
Pads for optional level shifters are included on the board and provide access to additional FPAA signals. These signals are not required and are not populated by default. If access to any of these signals is required, level shifter U7 and decoupling capacitors C24 and C25 must be installed. If the user desires to control the FPAA PORB (active low) signal from Arduino, Q2 must also be installed. This should not be required since the PORB signal is driven by the power-good output of the onboard regulator and the AN231 responds to a software reset command through the SPI interface.

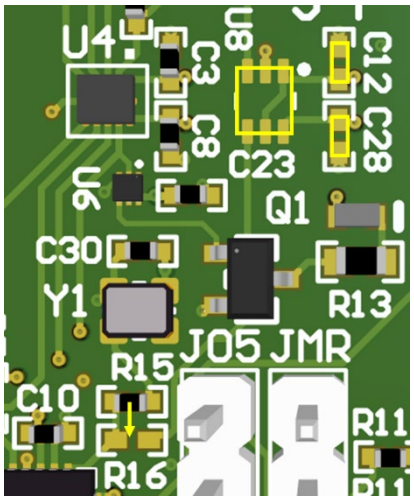




From the factory, the FPAA ACLK is driven by an onboard 16 MHz oscillator. The board can be modified to use D9 from the Arduino as the ACLK source by populating U8, C12, and C28 and moving the zero ohm resistor from R15 to R16.

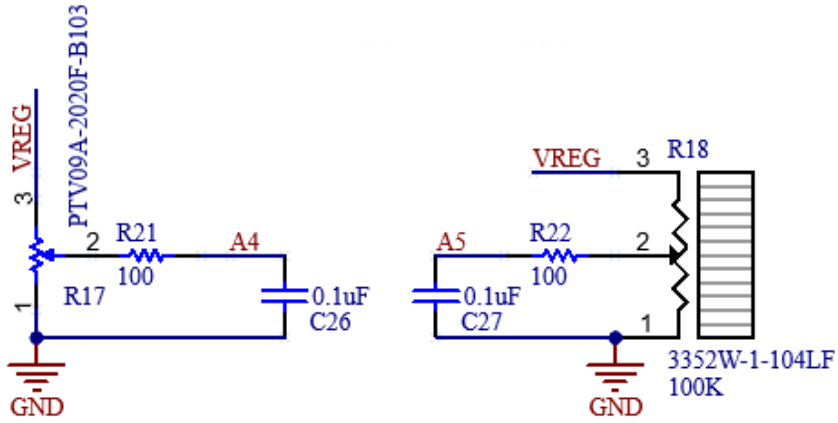


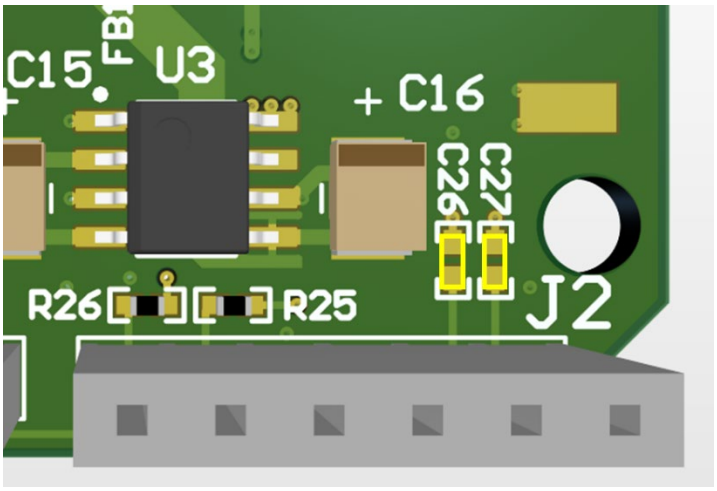




Optional Potentiometers

Pads for two potentiometers (R17, R18) are included on the OTC2312 to provide a convenient way to add control knobs. Capacitors (C26, C27) are not installed by default and can be added to provide filtering of the potentiometer voltage. Compatible part numbers are printed on the board for convenience. Alternatively, wires from panel mount potentiometers can be soldered into the holes. In a typical application, the position of R17 and/or R18 would be determined by using the ADC on Arduino inputs A4 and/or A5, and then software would be used to update the FPAA configuration.





Revision History

Date	Description
3/26/2026	Initial Release