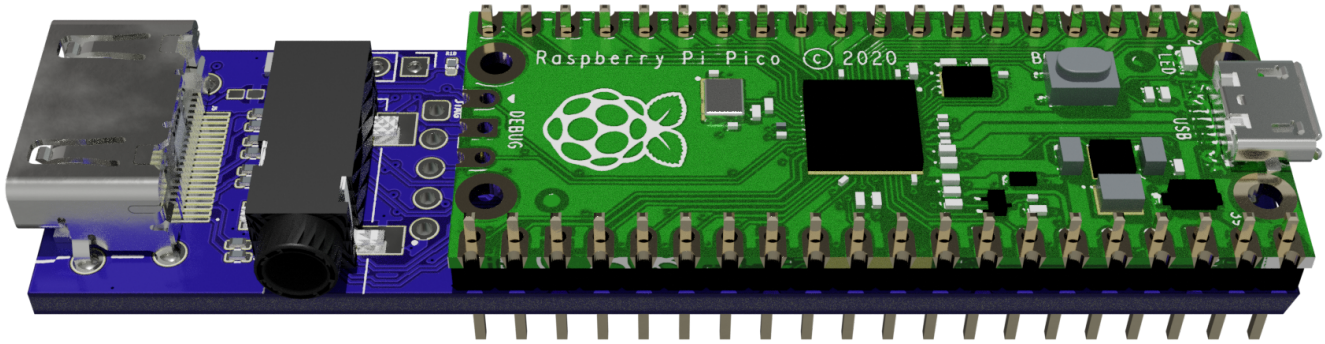
PicoFabric



General Description

The PicoFabric is a small FPGA module for the Raspberry Pi Pico. The board comes with a Pico pre-soldered or headerless. The device can be plugged directly into a breadboard for rapid prototyping and comes with a Visual Stuidio Code IDE for Simulating, Building and programming on any platform. Integrates seamlessly with c/c++ or MicroPython for rapid development.

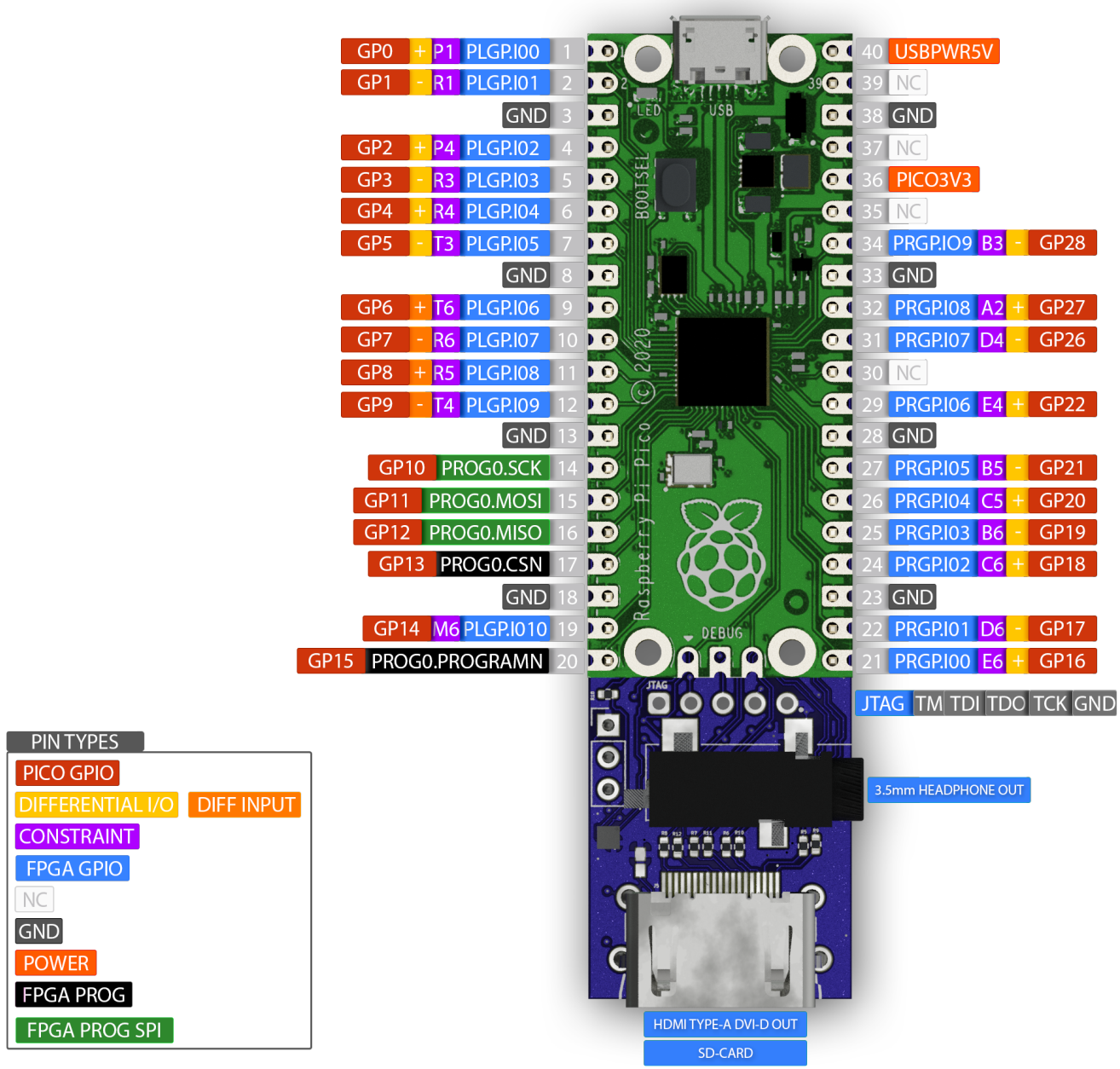
Key features

- Lattice ECP5 based fpga with 12k logic elements.
- FPGA bit-stream uploaded from the attached Raspberry Pi Pico using provided C and Micropython library or UF2 bit-stream loader, A JTAG port is also available.
- Dual HyperRAM storage from 16 to 32 MB of storage.
- Mirco SD Card storage.
- Audio DAC with with amplified headphone output.
- HDMI Type-A connector with DIV-D video output.
- Shared GPIO with Pico (A 200 ohm resistor is placed between the FPGA and the Pico/External IO)
- Visual Studio Code development extension for easier to use tooling, simulate, build and program on Windows, Mac And Linux.
- On-board LED.
- Breadboard friendly.

Applications

- FPGA development
- CPU Softcore development
- DVI-D Video output
- Audio playback
- Emulation

Pinout



J2 Connector

Pin	Pin name	Constraint	Pico	Description
1	PLGP.IO0	P1	GP0	GPIO 0, Differential I/O
2	PLGP.IO1	R1	GP1	GPIO 1, Differential I/O -
3	GND			GROUND
4	PLGP.IO2	P4	GP2	GPIO 2, Differential I/O
5	PLGP.IO3	R3	GP3	GPIO 3, Differential I/O -

6	PLGP.IO4	R4	GP4	GPIO 4, Differential I/O
7	PLGP.IO5	T3	GP5	GPIO 5, Differential I/O -
8	GND			GROUND
9	PLGP.IO6	T6	GP6	GPIO 6, Differential Input
10	PLGP.IO7	R6	GP7	GPIO 7, Differential Input -
11	PLGP.IO8	R5	GP8	GPIO 8, Differential
12	PLGP.IO9	T4	GP9	GPIO 9, Differential -
13	GND			GROUND
14	PROG0.SCK		GP10	FPGA SPI programming interface Clock signal.
15	PROG0.MOSI		GP11	FPGA SPI programming interface MOSI pin.
16	PROG0.MISO		GP12	FPGA SPI programming interface MISO pin.
17	PROG0.CSN		GP13	FPGA SPI programming interface Chip select pin.
18	GND			GROUND
19	PLGP.IO10	M6	GP14	GPIO 10
20	PROG0.PROGRAMN		GP15	FPGA Program dedicated mode pin, not usable for GPIO.

J3 Connector

Pin	Pinname	Constraint	Pico	Description
21	PRGP.IO0	E6	GP16	GPIO 0, Differential
22	PRGP.IO1	D6	GP17	GPIO 1, Differential -
23	GND			GROUND
24	PRGP.IO2	C6	GP18	GPIO 2, Differential
25	PRGP.IO3	B6	GP19	GPIO 3, Differential -
26	PRGP.IO4	C5	GP20	GPIO 4, Differential
27	PRGP.IO5	B5	GP21	GPIO 5, Differential -

28	GND			GROUND
29	PRGP.IO6	E4	GP22	GPIO 6, Differential
30	NC			
31	PRGP.IO7	D4	GP26	GPIO 7, Differential -
32	PRGP.IO8	A2	GP27	GPIO 8, Differential
33	GND			GROUND
34	PRGP.IO9	B3	GP28	GPIO 9, Differential -
35	NC			Pico ADC Vref, not connected to FPGA.
36	PICO3V3SRC		3V3(out)	Pico 3.3v output, Not used by the FPGA by default.
37	NC		3V3_EN	Pico 3.3v enable pin, Not used by the FPGA.
38	GND			GROUND
39	NC			
40	USBPWR5V			Power input from Pico USB port, powers the onboard 3.3V, 2.5v and 1.8v regulators.

- All GPIO at 3.3v (LVCMOS33) voltage levels.

JTAG Pin header

Pin	Pin name	Description
1	JTAG0.TMS	JTAG Test mode select.
2	JTAG0.TDI	JTAG Test data in.
3	JTAG0.TDO	JTAG Test data out.
4	JTAG0.TCK	JTAG Test clock.
5	GND	JTAG Ground pin.

PicoFabric Development IDE

A Visual Studio Code development plugin is provided to simulate, build and program the PicoFabric. See (https://github.com/picolemon/picofabric-ide) documentation on getting started.

- Simulate VHDL
- Built in VCD viewer
- Build bitstreams & program device

Open source development tool

Tool such as app.io can be used to develop bitstreams, simply grab the constraints and drop into your project and upload using either open source tools or the program.py UF2 programmer.

Constraints

https://github.com/picolemon/picofabric-hardware/constraints/fabric12k.lpf

Device programming

The board has no flash and relies on the attached Pico to store and send the BitStream over SPI at power up. Other devices such as an ESP-32 can also be use to program the FPGA over SPI.

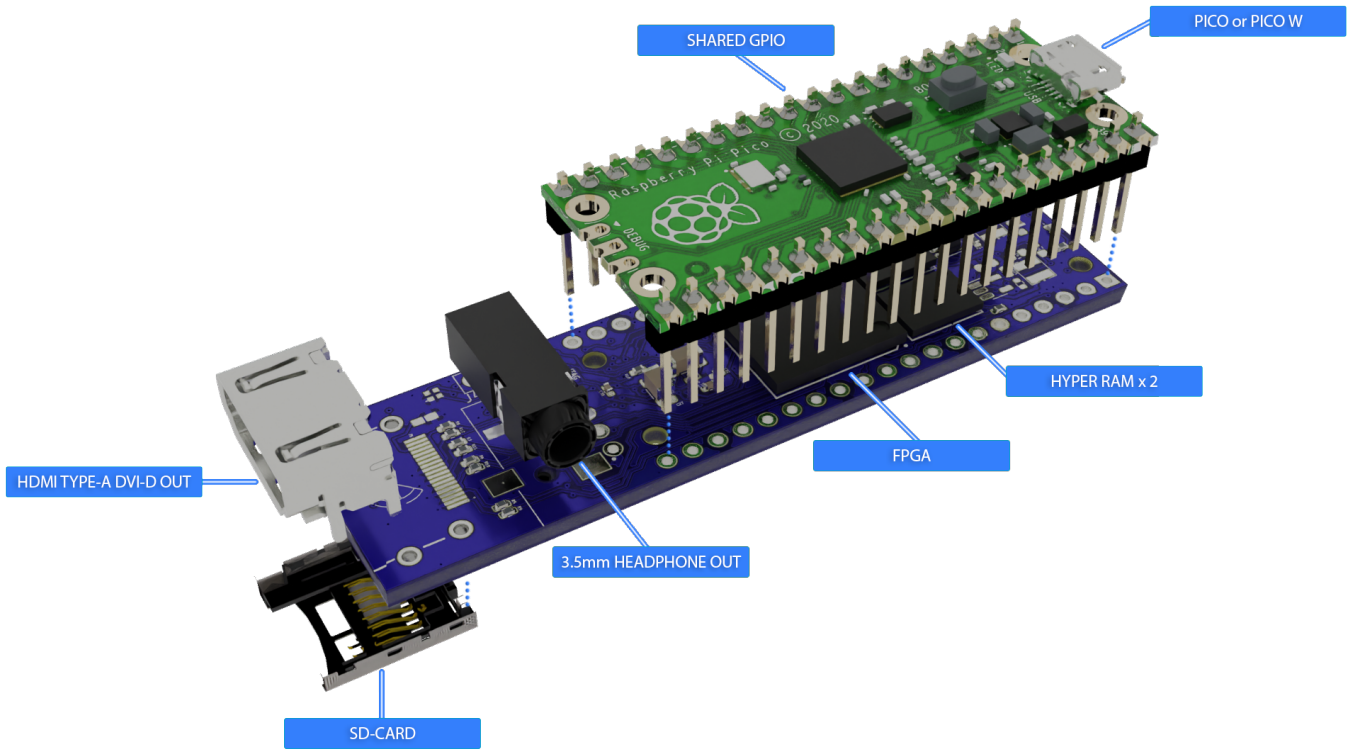
The preferred way is to program the FPGA using an UF2 bootloader, this firmware runs on the Pico and provides a serial interface and flash storage for the Bit stream. The PicoFabric IDE provides a built in programmer that can program the FPGA using the pre-programmed Pico.

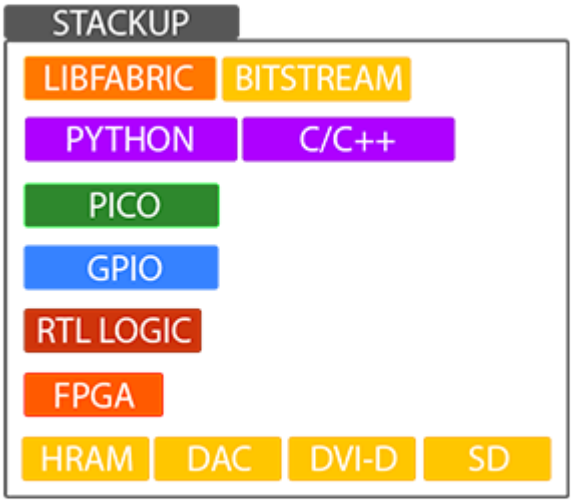
A CLI programmer is available from here https://github.com/picolemon/picofabric-hardware/programmer

Open source programming over JTAG can be achieved using ecpprog over the standard JTAG pins. soldering is required to attach a female pin header and can be used with any FT2232HL based JTAG board eg. ESP-Prog.

Programming can also be done over SPI, pins 14-17 can be used to program the device from another MCU such as an ESP-32.

Stackup





Micro python

The MicroPython SDK(https://github.com/picolemon/picofabric-micropython) provides bit stream programming and libraries to communicate with the FPGA. For example python code on the Pico can send Display commands to the FPGA acting as a simple GPU.

HyperRam

The dual onboard HyperRam storage can be used for general storage and can be independently accessed. The differential clocks not supported or tested at the time of writing but are connected for future use. A few examples(https://github.com/picolemon/picofabric-examples) on ram access are provided.

DVD-D

A non-compliant DVI-D port is available for video output over Micro HDMI, an adapter will be required to connect to a full size HDMI cable. This style of port was chosen due to size constraints. Basic HDMI signalling example are provided here (https://github.com/picolemon/picofabric-examples)

Audio DAC

An I2S audio DAC with an amplified headphone output can output directly to a set of connected headphones. To use the DAC a few SPI commands are require to initialise the volume and outputs. Examples are provided to setup and play back audio here (https://github.com/picolemon/picofabric-examples)

Micro SD Card

The Micro SD Card reader is attached to the FPGA for general use, the provided example use a passthrough so standard c libraries can be used.

Part Numbers

Mfr#	Desc
LFE5U-12F-6BG256C	FPGA Device.
PCM1774RGPR	Audio DAC Device.

W958D8NBYA5I	HyperRAM device.

Links

Hardware Github: https://github.com/picolemon/picofabric-hardware

MicroPython SDK Github: https://github.com/picolemon/picofabric-micropython

C/C++ SDK Github: https://github.com/picolemon/picofabric-c

PicoFabric IDE Github: https://github.com/picolemon/picofabric-ide

Examples Github: https://github.com/picolemon/picofabric-examples

Product page: https://picolemon.com/board/picofabric

Change history

03-07-23: Initial version.

Contact & support

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