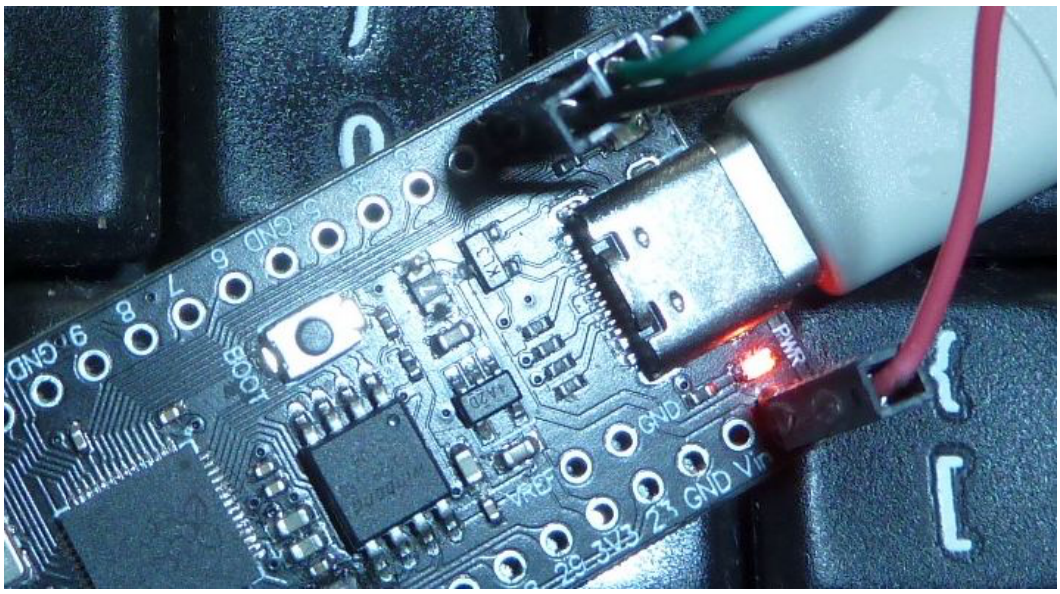
Oktober 2023

noForth website

Pico RP2040 dev boards with noForth t(v) (duo)

In this text we refer to these two documents:
- RP2040 datasheet
- Armv6-M Architecture Reference Manual

1. RP2040 Pico dev boards



Core : M0+ core with ARMv6-M ISA
Kit Contents: Various Pico Dev Boards

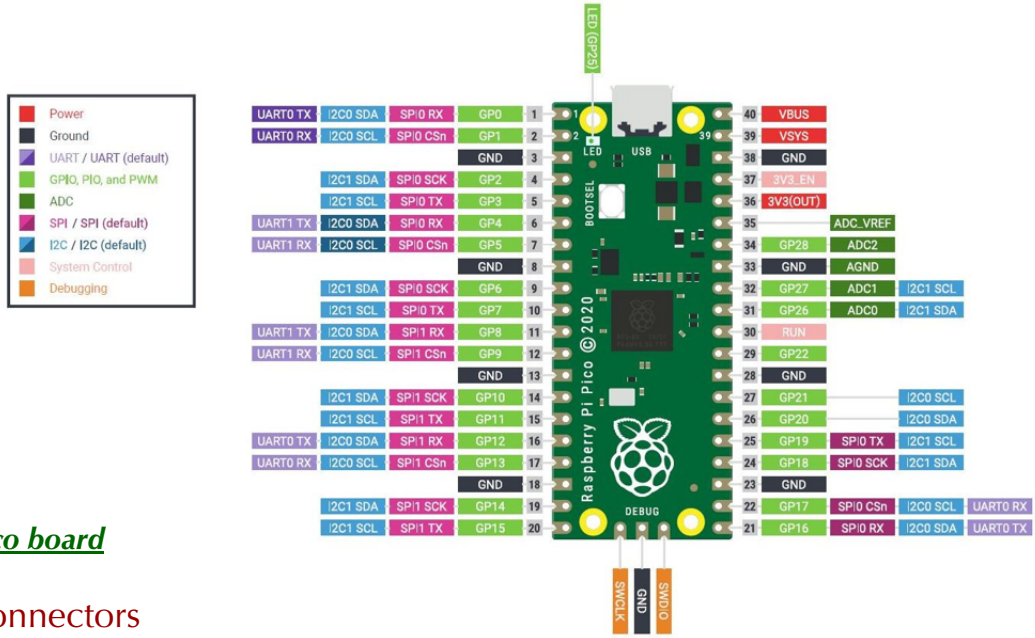
- Antratek: Pico dev board
- Kiwi: Pico dev board
- VCC-GND: YP-RP2040 board
- YP-RP2040 alternative board

i/o port connections pico

Between parens are the pin usage differences between the original Pico and the YD-RP2040

GPIO

```
GPIO0  - UART0 TX  GPIO16 - ...
GPIO1  - UART0 RX  GPIO17 - ...
GPIO2  - ...       GPIO18 - ...
GPIO3  - ...       GPIO29 - ...
GPIO4  - UART1 TX  GPIO20 - ...
GPIO5  - UART1 RX  GPIO21 - ...
GPIO6  - ...       GPIO22 - ...
GPIO7  - ...       GPIO23 - SMPS (WS2812)
GPIO8  - ...       GPIO24 - VBUS sense (switch)
GPIO9  - ...       GPIO25 - LED
GPIO10 - ...       GPIO26 - ...
GPIO11 - ...       GPIO27 - ...
GPIO12 - ...       GPIO28 - ...
GPIO13 - ...       GPIO29 - VSYS (...)
GPIO14 - ...
GPIO15 - ...
```



Pico board

Connectors

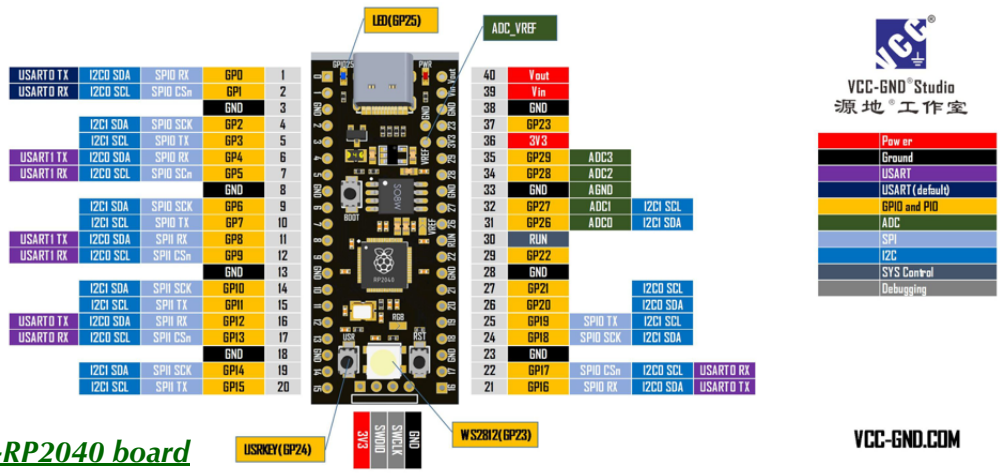
```
J0      = i/o GPIO and GND
        = i/o GPIO, RUN, GND, 5V, 3V3, 3V3_EN and ADC_VREF
J1      = USB-C Programming connector
J2      = Debug (SWD) port
```

Hardware Pico

- LED on GPIO25
- Switch BOOTSEL on QSPI_SS
- SPI Flash (16 to 128 Mbit)
- 12MHz crystal

Hardware YD-RP2040

- LED on GPIO25, power LED & WS2812 LED on GPIO23
- Three switches BOOTSEL on QSPI_SS, reset & GPIO24 (user)
- SPI Flash (32 to 128 Mbit)
- 12MHz crystal



YD-RP2040 board

Only the board pins 35 & 37 are connected differently, see pictures.
pin 35 = GPIO29, pin 37 = GPIO23

2. i/o ports

I/O port addresses

The port registers are memory mapped.
First the base addresses for the I/O-port:

```
SIO base     = D0000000
User bank    = 40014000 (Two cells for each pin)
```

Port register offsets for SIO base

More functionality can be found from page 42ff.

Label	SIO base	Function
CPUID	00	Processor core ID
GPIO_IN	04	Input value for GPIO
GPIO_HI_IN	08	Input value for QSPI
GPIO_OUT	10	Output value
GPIO_SET	14	Output value set
GPIO_CLR	18	Output value clear
GPIO_XOR	1C	Output value toggle
Etc.		

Values for port control IO_BANK0_BASE registers

On page 13 & 14 of the RP2040 datasheet, you find a complete list of all functions that can be chosen for each GPIO pin. The pin control functions starts at offset+4 for GPIO0 and are increased by 8 for each next pin.

	Function								
GPIO	F1	F2	F3	F4	F5	F6	F7	F8	F9
0	SPI0 RX	UART0 TX	I2C0 SDA	PWM0 A	SIO	PIO0	PIO1		USB OVCUR DET
1	SPI0 CSn	UART0 RX	I2C0 SCL	PWM0 B	SIO	PIO0	PIO1		USB VBUS DET
2	SPI0 SCK	UART0 CTS	I2C1 SDA	PWM1 A	SIO	PIO0	PIO1		USB VBUS EN
3	SPI0 TX	UART0 RTS	I2C1 SCL	PWM1 B	SIO	PIO0	PIO1		USB OVCUR DET
4	SPI0 RX	UART1 TX	I2C0 SDA	PWM2 A	SIO	PIO0	PIO1		USB VBUS DET

```
1:  SPI-0 or 1
2:  UART-0 or 1
3:  I2C-0 or 1
4:  PWM-0 to PWM-7
5:  Standard I/O (Reset state)
6:  Programmable I/O (PIO-0)
7:  Programmable I/O (PIO-1)
8:  Clock in or out
9:  USB-bus
```

The reset value for all port control registers is 1F. More info in the 'RP2040 datasheet.PDF' from page 236ff.

3. RS232/USB driver

The USB chip for the SEED board is a dongle with the PL2303TA Prolific USB-chip. This chip needs a specific driver under Windows XP/7/8/10/11. Execute this file: PL2303-Prolific_DriverInstaller_v1200.exe. The default baudrate for the RP2040 controller is 460800 baud.

4a. noForth t memory map

RAM 21000000 - 21040000

```
21000000 IVECS      \ 48 vectors
     ... IVECS/     \ Vector table end
210000D0 HOT        \ Uhere starts here
21000200 ORIGIN     \ HERE starts here
\ ... system ...
2100xxxx HERE       \ Current systems end
2101F800 ...        \ Systems end
2101F800 FLYBUF     \ Flyer buffer (400 bytes)
2101FC00 FLYBUF/    \ End of flyer buffer
2101FD00 SP0        \ Data stack (100 bytes grows down)
2101FF00 RP0        \ Return stack (200 bytes grows down)
2101FF00 TIB        \ Input buffer (100 bytes)
21020000 TIB/
21040000 MEMTOP     \ End of RAM memory
```

RAM 20040000 - 20042000

8 kByte of free RAM memory in two 4 kByte banks.

4b. noForth t duo memory map

noForth t memory map core-0
RAM 21000000 - 21020000

```
21000000 IVECS      \ 48 vectors
     ... IVECS/     \ Vector table end
210000D0 HOT        \ Uhere starts here
21000200 ORIGIN     \ HERE starts here
\ ... system ...
2100xxxx HERE       \ Current systems end
2101F800 ...        \ Systems end
2101F800 FLYBUF     \ Flyer buffer (400 bytes)
2101FC00 FLYBUF/    \ End of flyer buffer
2101FD00 SP0        \ Data stack (100 bytes grows down)
2101FF00 RP0        \ Return stack (200 bytes grows down)
2101FF00 TIB        \ Input buffer (100 bytes)
21020000 TIB/
21020000 MEMTOP     \ End of core-0 RAM memory
```

noForth t memory map core-1
RAM 21020000 - 21040000

```
21020000 IVECS      \ 48 vectors
     ... IVECS/     \ Vector table end
210200D0 HOT        \ Uhere starts here
21020200 ORIGIN     \ HERE starts here
\ ... system ...
2102xxxx HERE       \ Current systems end
2103F800 ...        \ Systems end
2103F800 FLYBUF     \ Flyer buffer (400 bytes)
2103FC00 FLYBUF/    \ End of flyer buffer
2103FD00 SP0        \ Data stack (100 bytes grows down)
2103FF00 RP0        \ Return stack (200 bytes grows down)
2103FF00 TIB        \ Input buffer (100 bytes)
21040000 TIB/
21040000 MEMTOP     \ End of core-1 RAM memory
```

RAM 20040000 - 20042000

8 kByte of free RAM memory in two 4 kByte banks.

4c. FLASH ROM (XIP mode) 10000000 - 1003FFFF

```
 10000000  Secundairy boot code, loads image-1 on startup
 10000100  Image-1   \ Cold start image invoked by COLD to
 10043000  Image-2   \ Spare image invoked by COLD2
 10083000  Free      \ Start of free flash space
```

- TIB/ is a changeable uvalue (Udata).
- Udata is saved by FREEZE too.
- At start-up (and reset or COLD) noForth moves from Flash to RAM.

5. Interrupt vector table

See 'RP2040 datasheet.PDF' for more details (page 60ff) and 'ARMv6-M Architecture Reference Manual.pdf' from page 218ff. The table is pointed to by the VTOR register at PPB_BASE + ED08. Note that the low 8 bits of VTOR are always zero , so it's 256 bytes page aligned.

```
RP2040 exceptions:
0000  00 - Length of noForth image
0004  01 - Reset vector
0008  02 - NMI handler
000C  03 - Hard fault handler
0010  04 - MPU fault handler
0014  05 - Reserved
0018  06 - Reserved
001C  07 - Reserved
0020  08 - Reserved
0024  09 - Reserved
0028  10 - Reserved
002C  11 - Supervisor call handler
0030  12 - Reserved
0034  13 - Reserved
0038  14 - Pend supervidor handler
003C  15 - Systick handler

NVIC IRQ interrupts:
0040  00 - Timer IRQ 0
0044  01 - Timer IRQ 1
0048  02 - Timer IRQ 2
004C  03 - Timer IRQ 3
0050  04 - PWM IRQ wrap
0054  05 - USB vontrol IRQ
0058  06 - XIP IRQ
005C  07 - PIO 0 IRQ 0
0060  08 - PIO 0 IRQ 1
0064  09 - PIO 1 IRQ 0
0068  10 - PIO 1 IRQ 1
006C  11 - DMA IRQ 0
0070  12 - DMA IRQ 1
0074  13 - IO IRQ bank 0
0078  14 - IO IRQ QSPI
007C  15 - SIO IRQ proc 0
0080  16 - SIO IRQ proc 1
0084  17 - Clock IRQ
0088  18 - SPI 0 IRQ
008C  19 - SPI 1 IRQ
0090  20 - UART 0 IRQ
0094  21 - UART 1 IRQ
0098  22 - ADC IRQ fifo
009C  23 - I2C 0 IRQ
00A0  24 - I2C 1 IRQ
00A4  25 - RTC IRQ
00A8  26 - Connected to zero
00AC  27 - Connected to zero
00B0  28 - Connected to zero
00B4  29 - Connected to zero
00B8  30 - Connected to zero
00BC  31 - Connected to zero
```