PY32F003L24D6TR MCU Dev Board

DEVLAB FACTOR

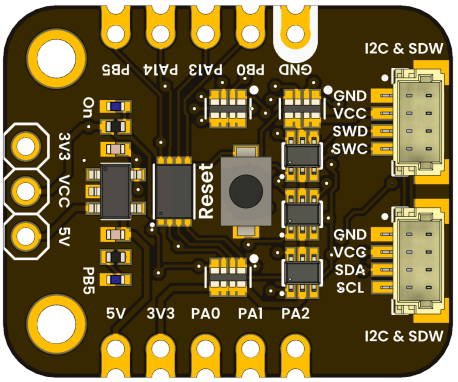
Mfr. Part #: UE0102

Product Reference Manual (V1.0)

Description

The **DevLab Development Board**, powered by the **PY32F003L24D6TR** microcontroller, provides an efficient and compact platform for **rapid prototyping, embedded systems education, IoT experimentation, and wearable technology development**. Its design emphasizes flexibility and simplicity, integrating essential features that allow developers to focus on innovation rather than complex setups. The board operates around a **32-bit ARM® Cortex®-M0 core** running up to **24 MHz**, with **16 KB of Flash** and **2 KB of SRAM**, offering an ideal balance between processing performance and memory efficiency. This configuration enables smooth execution of control algorithms, communication routines, and sensor data processing across a wide range of embedded applications.

To complement its processing capability, the DevLab board includes a rich set of **onboard peripherals** and **hardware conveniences**. Interfaces such as **SPI, I²C, and UART** simplify communication with external modules and sensors, while the **12-bit ADC** and **dual comparators** support precise analog signal acquisition. The integrated **5 V → 3.3 V voltage regulator**, **4-pin JST 1.0 mm connector** for programming and I²C communication, **reset button**, and **status LED on PB5** streamline both debugging and prototyping. Furthermore, the board maintains **level-shifter compatibility** between **3.3 V and 5 V logic**, ensuring seamless operation with a broad ecosystem of peripherals.



Key Features

- **ARM® Cortex®-M0 Core:** 32-bit RISC processor running up to 24 MHz, optimized for real-time control and low-power operation.
- **Compact and Efficient Design:** Designed for embedded and IoT applications requiring small form factor and low energy consumption.
- **Wide Operating Voltage:** Fully functional from **1.7 V to 5.5 V**, suitable for battery or USB-powered systems.
- **Onboard Voltage Regulator:** Integrated **5 V → 3.3 V LDO regulator**, ensuring stable MCU operation from USB or external 5 V supply.
- **Communication Interface:** **4-pin JST 1.0 mm connector** for **programming and I²C communication**, compatible with standard DevLab and Qwiic wiring schemes.
- **User Interface Components:**
- **Reset Button:** Allows manual restart of the microcontroller.
- **Status LED (PB5):** Blinks for power or firmware activity indication.
- **Analog and Timing Peripherals:**
    - 12-bit ADC

  - 2 analog comparators
  - 1 advanced and 4 general-purpose 16-bit timers
  - Low-power timer, SysTick, and dual watchdogs
- **Communication Peripherals:** 1× SPI, 1× I²C, 1× USART.
- **Level Shifter Compatibility:** Fully supports logic level interfacing between **3.3 V and 5 V** systems, ensuring cross-platform signal safety.
- **Operating Environment:** −40 °C to +85 °C industrial temperature range.

DevLab format compatibility.

The DevLab format is a standardized hardware layout that exposes the majority of the microcontroller or integrated circuit functional pins, including connections for external sensors, converters, and other peripheral devices. It provides direct access to I²C, SPI, UART, and additional communication interfaces for flexible hardware interaction.

Software Support

- **Arduino IDE**
- **Py32f0xx-hal/ VS Code:**
- https://github.com/UNIT-Electronics-MX/py32f0xx-hal
  Supports development with automated builds, serial monitoring, and advanced debugging projects.

Applications

- **Consumer Electronics:** Smart home devices, small appliances, and battery-powered gadgets.
- **Industrial Control:** Sensor interfaces, automation modules, power monitoring, and fan controllers.
- **IoT Devices:** Environmental data loggers, wireless bridge modules, smart meters, and wearable submodules.
- **Lighting Systems:** RGB/NeoPixel LED controllers, PWM dimmers, and sound-reactive lighting.
- **Education & Prototyping:** Training kits, MCU programming practice, and portable debugging tools.
- **Interface Control:** I²C/SPI bridges, input devices, touch keys, and DAC-based tone generators.

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1 The Board

1.1 Accessories

- 1×6-pin 2.54 mm male header

2 Ratings

2.1 Recommended Operating Conditions

Symbol	Description	Min	Typ	Max	Unit
VDD	Operating supply voltage	1.7	3.3	5.5	V
IDD	Supply current (active mode @ 24 MHz)	—	3.0	8.0	mA
ISTBY	Standby current	—	1.2	3.0	µA
FCPU	CPU operating frequency	—	24	48	MHz
TA	Ambient operating temperature	−40	25	+85	°C
VIN_IO	Input voltage on I/O pins	0	—	5.5	V
VOUT_IO	Output voltage on I/O pins	0	—	5.5	V
VREG	Onboard regulator input (5 V to 3.3 V LDO)	4.5	5.0	5.5	V
VIL	Input low voltage threshold	—	—	0.3 × VDD	V
VIH	Input high voltage threshold	0.7 × VDD	—	—	V

3 Functional Overview

This section describes the functional behavior of the device I/O system, including voltage characteristics, port structures, reset behavior, and register-based function selection. It is intended to provide a clear understanding of how pins operate at electrical and configuration levels

	Pin Name / Reset	Port Type	Port Structure	Notes	Multiplexing Functions	Additional Functions
1	VCC	S	—	—	Digital power supply	—
2	PA0	I/O	COM	—	USART1_CTSCOMP1_OUTTIM1_CH3TIM1_CH1NSPI1_MISOIR_OUT	ADC_IN0COMP1_INM
3	PA1	I/O	COM	—	SPI1_SCKUSART1_RTSEVENTOUTSPI1_MOSI	COMP1_INPADC_IN1
4	PA2	I/O	COM	—	TIM1_CH4TIM1_CH2NMCOSPI1_MOSIUSART1_TXCOMP2_OUTSPI1_SCKTIM3_CH1I2C_SDA	COMP2_INMADC_IN2
5	PB0	I/O	COM	—	MCOSPI1_NSSTIM3_CH3TIM1_CH2NEVENTOUTCOMP1_OUT	ADC_IN8
6	PA10	I/O	COM	—	USART1_RXTIM1_CH3TIM17_BKINI2C_SDAEVENTOUTI2C_SCLSPI1_NSSUSART1_TXIR_OUT	OS32IN
6	PF2-NRST	I/O	RST	(1)	MCO	NRST

6	PA13 (SWDIO)	I/O	COM	(2)	SWDIOIR_OUT	—
7	PA14 (SWCLK)	I/O	COM	(2)	EVENTOUTSPI1_MISOTIM1_CH2USART1_RXMCOSWCLKUSART1_TX	—
8	PB6	I/O	COM	—	USART1_TXTIM1_CH3TIM16_CH1NI2C_SCLLPTIM_ETREVENTOUTSPI1_MOSI	COMP2_INP
8	PB5	I/O	COM_L	—	SPI1_MOSITIM3_CH2TIM16_BKINUSART1_CKLPTIM_IN1COMP1_OUT	—

Notes

1. Selection between **PF2** or **NRST** is configured through option bytes.
2. After reset, **PA13** and **PA14** are configured as **SWDIO** and **SWCLK** respectively; PA13 has an internal pull-up resistor, PA14 an internal pull-down resistor.

3.2 Port Types and Electrical Structures

Each pin is classified by **port type** and **port structure**, which define its electrical behavior and supported functions.

- **S (Supply pin):** Provides power to the device. No configurable function.
- **G (Ground pin):** Electrical reference for all internal circuits.
- **I/O (Input / Output pin):** General-purpose bidirectional pin supporting digital, analog, and alternate functions.

Port structures define functional capabilities:

- **COM (Common port):** Supports digital I/O, analog input, analog output, and alternate peripheral functions.
- **COM_L (Limited common port):** Supports digital and alternate functions with restricted analog capability.
- **RST (Reset port):** Dedicated reset structure with an internal weak pull-up resistor. Analog input and output functions are not supported on this port.

3.3 Reset Behavior and Default Pin State

After power-on reset or external reset:

- All I/O pins are configured as **floating inputs**, unless otherwise specified.
- Pull-up and pull-down resistors are disabled by default.
- Alternate functions are inactive until explicitly enabled by software.

Special cases:

- **PA13 and PA14** are automatically configured as **SWDIO** and **SWCLK** after reset to allow debug access.
    - PA13: internal pull-up enabled
    - PA14: internal pull-down enabled

The reset pin function (PF2 / NRST) selection is controlled through **option bytes**.

3.2 Function Selection and Multiplexing

Each I/O pin can provide multiple functions. The active function is selected as follows:

- **Multiplexing functions**
  Selected through the `GPIOx_AFR` (Alternate Function Register). These functions include peripheral signals such as USART, SPI, I²C, timers, comparators, and event outputs.
- **Additional functions**
  Enabled or selected directly through the corresponding peripheral configuration registers. These typically include analog inputs, comparator inputs, clock sources, and reset functions.

A complete multiplexing function mapping (AF0–AF15) for each pin is provided in **Appendix 9.2 – Multiplexing Cortex Mapping**.

3.4 Function Selection Architecture

Each I/O pin can perform multiple functions, selected through a layered configuration model.

3.4.1 GPIO Mode Selection

The base operating mode of a pin (input, output, analog, alternate) is controlled through GPIO configuration registers. This defines the electrical behavior of the pin before any peripheral assignment.

3.4.2 Multiplexed Alternate Functions

Alternate peripheral functions are selected through the **GPIOx_AFR (Alternate Function Register)**.

- Each pin supports up to **16 alternate functions (AF0–AF15)**.
- Only one alternate function can be active at a time.
- Functions include communication peripherals, timers, comparator outputs, event routing, and clock outputs.

Unused AF positions are reserved and must not be selected.

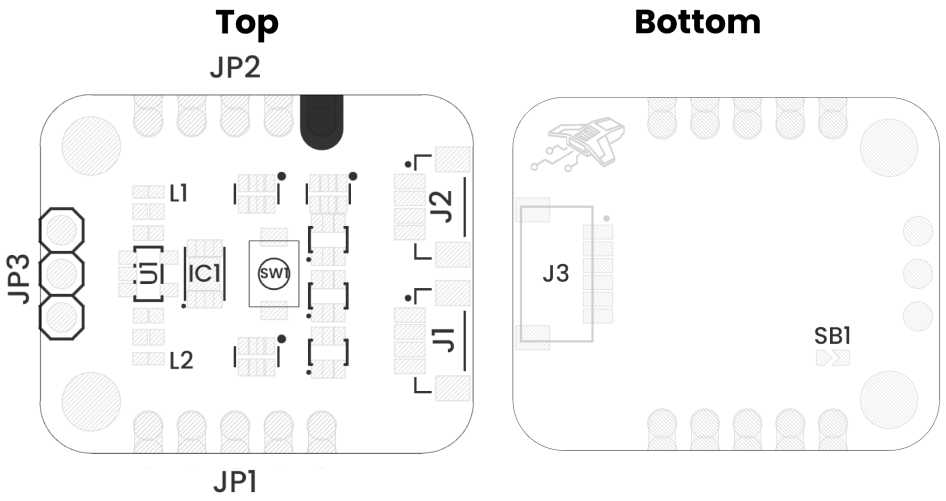
3.5 Additional and Direct Peripheral Functions

Some pin functions are **not selected through the AFR register**, but are enabled directly by peripheral control registers. These include:

- ADC input channels
- Comparator positive and negative inputs
- External clock sources
- Reset and debug interfaces

These functions override the digital path when enabled and require proper peripheral initialization.

3.2 Board Topology



Views of Board Topology

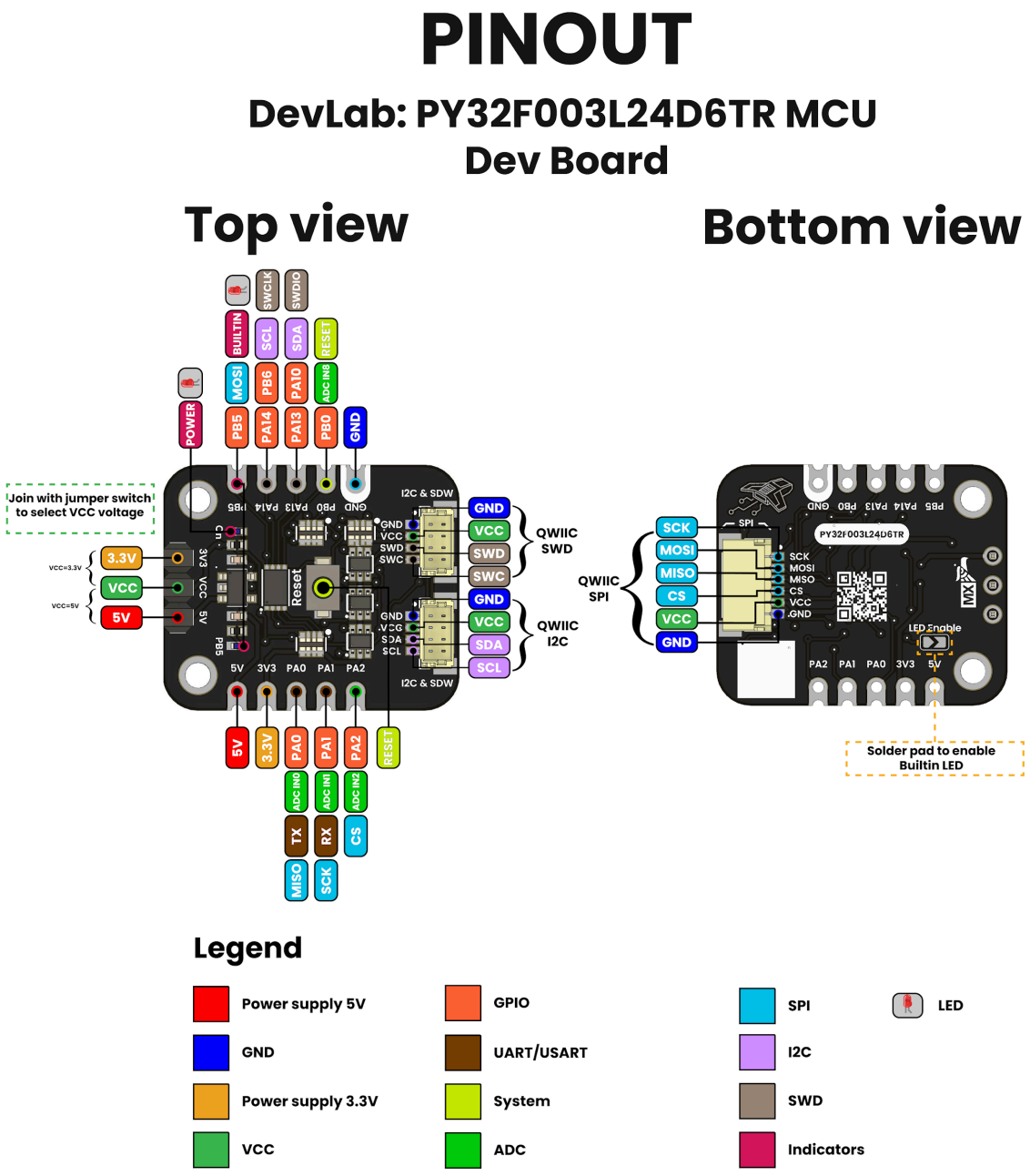
Views of PY32F003L24D6TR DevLab Topology

Table 3.2.1 - Components Overview

Ref.	Description
IC1	PY32F003L24D6TR Microcontroller
U1	AP2112K 3.3V Regulator
SW	Reset Push Button
L1	Power On LED
L2	Built In LED to PB5
J1	JST 1mm Connector for I2C or JTAG
J2	JST 1mm Connector for I2C or JTAG
J3	JST 1mm Connector for SPI
JP1	Header for GPIOs
JP2	Header for GPIOs
JP3	Header for Power Supply Selection
SB1	Solder Bridge to Enable LED Built In

4 Connectors & Pinouts

4.1 General Pinout



PY32F003L24D6TR DevLab *General Pinout*

4.2 Pinout General Description

Pin Label	Function / Notes
VCC	Power Input
GND	Ground
PA0	USART2_TX MISO
PA1	USART2_RX SCK
PA2	ADC_IN2 CS
PB0 / PF2	GPIO / NRST
PB5	LED Built In / GPIO / MOSI
PA13 / PA10	SWDIO / I2C_SCL
PA14 / PB6	SWCLK / I2C_SDA

5 Board Operation

5.1 Getting Started with arduino IDE

This section describes how to start using the PY32F0xx microcontroller boards with the Arduino IDE. It is intended to provide a functional onboarding guide and a conceptual overview of the development flow rather than a complete reference implementation.

Notice Arduino Core support for PY32 microcontrollers is currently partial and under active development.

The objective of this section is to help users understand:

- The programming workflow
- Toolchain integration
- Hardware interaction model
- The development direction of the platform

Supported Development Environment

Component	Description
IDE	Arduino IDE (latest stable version recommended)
Core	UNIT Electronics PY32 Arduino Core
Architecture	ARM Cortex-M0+
Toolchain	GNU Arm Embedded Toolchain
Programmer	CMSIS-DAP compatible debugger
Upload Tool	pyOCD

To get started, the following hardware is required:

- A supported PY32F0xx board
- A CMSIS-DAP compatible programmer/debugger
- USB cable
- Host computer (Linux or Windows)
- Recommended Programmer
- The officially recommended programmer for PY32 boards is:
    - CH552 Multi-Protocol Programmer (CMSIS-DAP) Developed by UNIT Electronics MX

      This programmer provides:

        - Native CMSIS-DAP support
        - Full compatibility with pyOCD
        - Cross-platform operation
        - Open-hardware transparency

Software Installation Overview

The Arduino workflow for PY32 boards consists of three software layers:

Arduino IDE> User interface, sketch editor, and build system.

PY32 Board Package provides:

- Board definitions
- Pin mapping
- Core Arduino APIs
- HAL integration
- pyOCD
- Handles flashing and debugging via CMSIS-DAP.

Adding the Board Package to Arduino IDE

- Open Arduino IDE
- Navigate to File → Preferences
- Add the following URL to Additional Boards Manager URLs:

https://raw.githubusercontent.com/UNIT-Electronics-MX/unit_electronics_py32_arduino_package/main/package_unit_electronics_py32_index.json

- Confirm and restart the IDE if required

Installing the PY32 Board Package

- Open Tools → Board → Boards Manager
- Search for PY32
- Install UNIT Electronics PY32 Board Package
- Wait for toolchain and core installation to complete
- After installation, PY32 boards will appear in the board selection list.

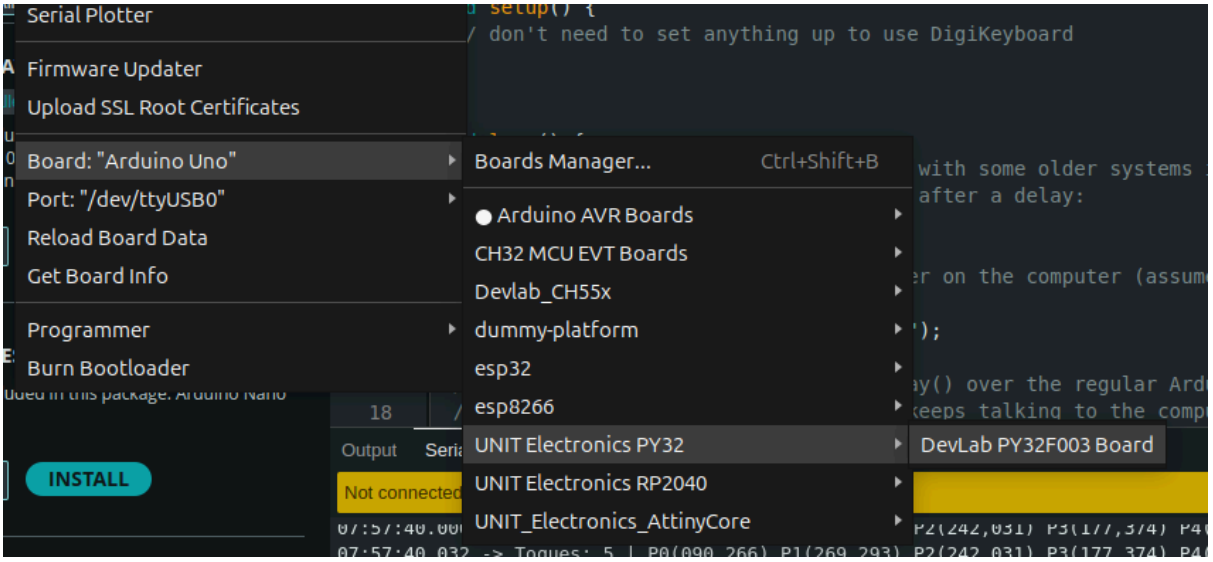
Programmer and Upload Tool Configuration

pyOCD Requirement

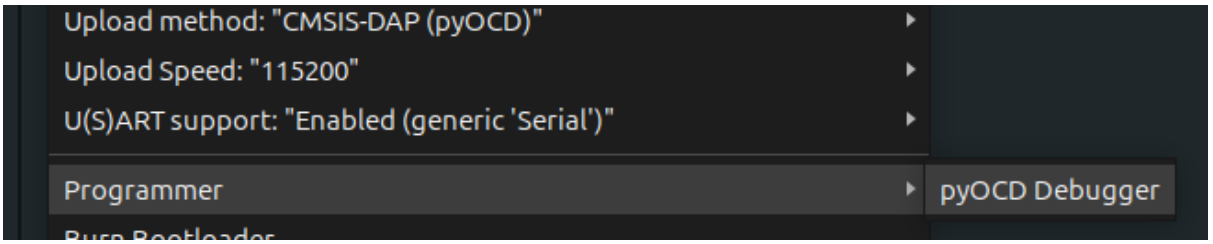
- All PY32 boards require pyOCD for firmware upload and debugging.
- pyOCD provides:
- CMSIS-DAP communication
- Flash programming
- Optional debug access
- Ensure: pyocd is available in the system PATH
- USB permissions are correctly configured (Linux: dialout group)

Board and Port Selection

1. Once hardware is connected:
2. Select your PY32 board under:
    a. Tools → Board →



3. Select the active port under:
    a. Tools → Port



    b. If no port appears:
        i. Verify CMSIS-DAP firmware
        ii. Check USB cable
4. Confirm pyOCD installation

First Upload Test

A basic sketch can be used to validate the setup:

```
void setup() {
 pinMode(LED_BUILTIN, OUTPUT);
 Serial.begin(115200);
}

void loop() {
 digitalWrite(LED_BUILTIN, HIGH);
 delay(1000);
 digitalWrite(LED_BUILTIN, LOW);
 delay(1000);
}
```

Successful LED blinking indicates:

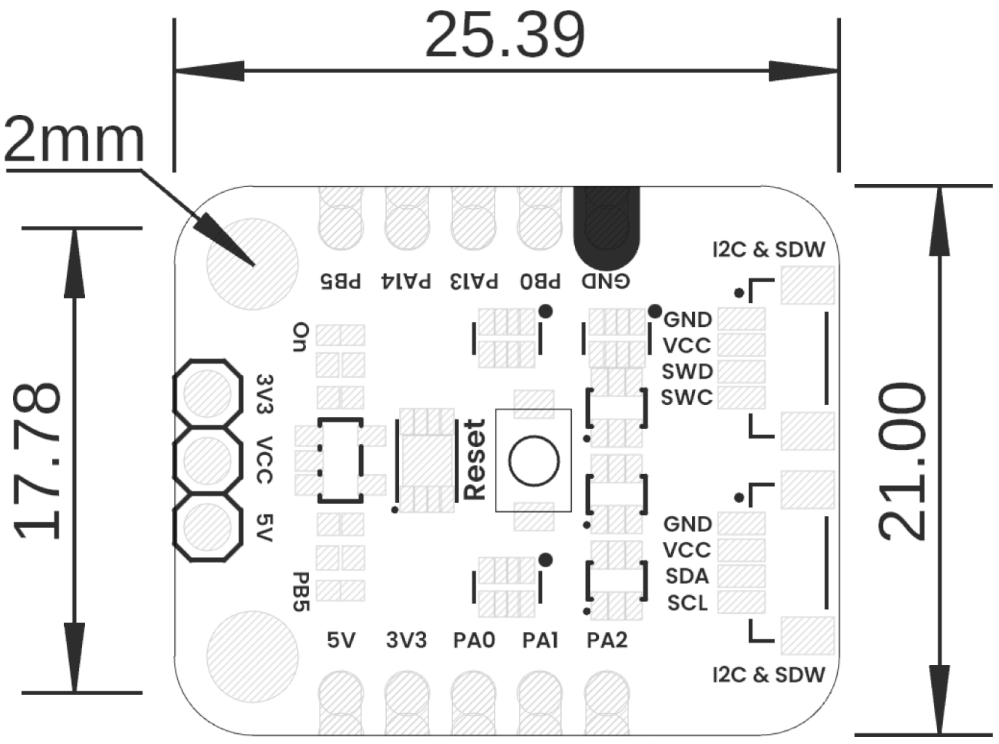
- Correct board configuration
- Functional upload chain
- Proper clock and GPIO setup

Functional Scope and Current Limitations

- The current PY32 Arduino Core provides:
- Implemented
- Core Arduino structure (setup() / loop())
- GPIO digital I/O
- UART (Serial)
- Timers (basic)
- Partial PWM support
- I2C basic: Not Fully Implemented
- Full Arduino library compatibility
- Advanced power modes
- High-level peripheral abstractions
- Integrated IDE debugging features

Users are encouraged to combine Arduino APIs with HAL-level understanding for advanced use cases.

6 Mechanical Information



Board Dimensions in Millimeters

Mechanical dimensions in millimeters

7 Company Information

Company name	UNIT Electronics
Company website	https://uelectronics.com/
Company Address	Salvador 19, Cuauhtémoc, 06000 Mexico City, CDMX

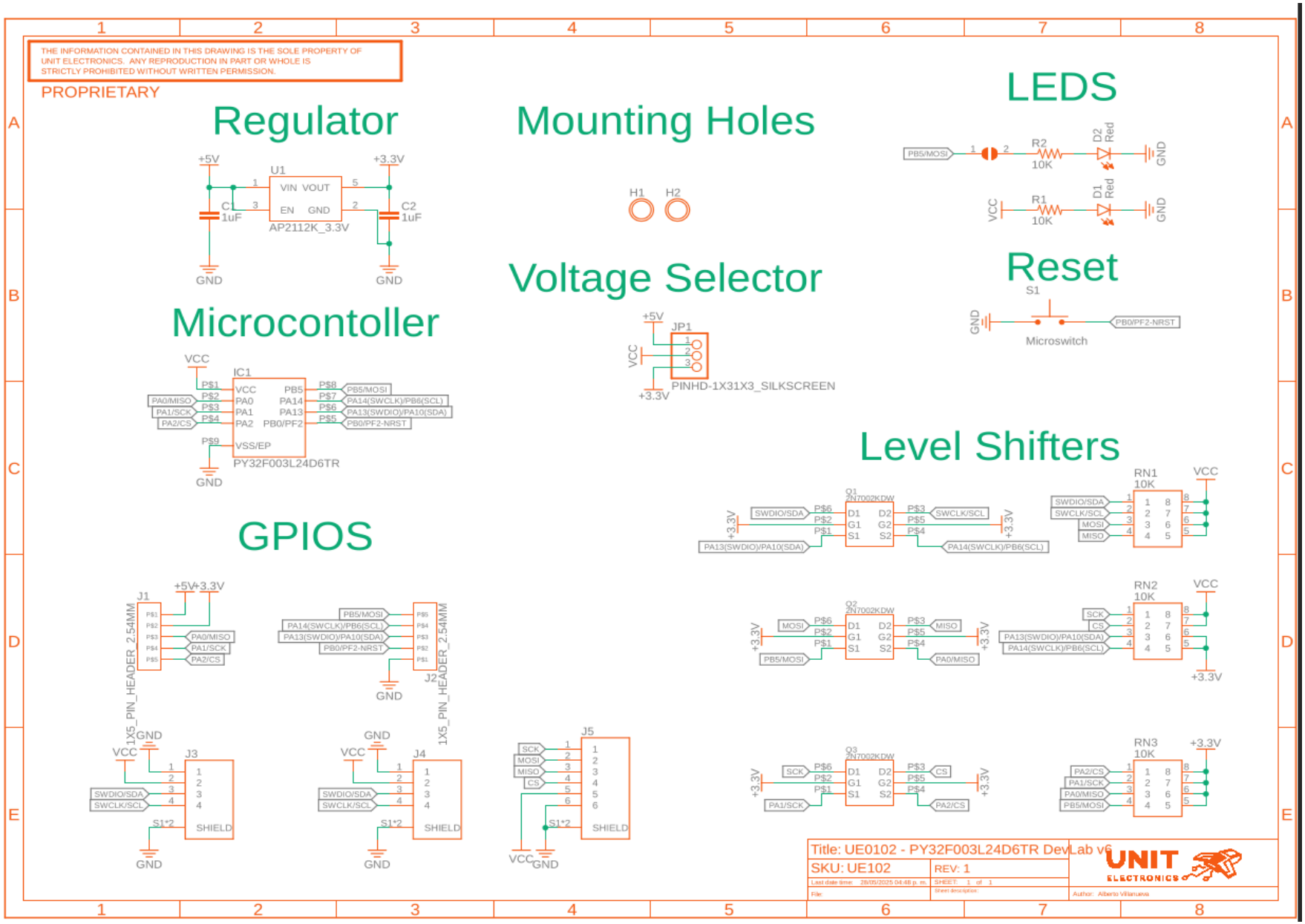
8 Reference Documentation

Ref	Link
Documentation	https://github.com/UNIT-Electronics-MX/unit_devlab_py32f003l24d6tr_development_board
Unit Electronics Library for Arduino Package	https://github.com/UNIT-Electronics-MX/unit_electronics_py32_arduino_package
Getting Started Guide	https://unit-electronics-mx.github.io/unit_devlab_py32f003l24d6tr_development_board
Wiki	https://wiki.uelectronics.com/wiki/devlab_py32f003l24d6tr_mcu_dev_board
Arduino IDE	https://www.arduino.cc/en/software
Visual Studio Code	https://code.visualstudio.com/download
PY32F003 - DataSheet	https://download.py32.org/Datasheet/en/PY32F003_Datasheet_Rev1.7.pdf

9 Appendix

9.1 Schematic

(*https://github.com/UNIT-Electronics-MX/unit_devlab_py32f003l24d6tr_development_board/blob/main/hardware/unit_schematic_v_0_0_1_ue0102_PY32f003L24D6TR_devlab.pdf*)


THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF UNIT ELECTRONICS. ANY REPRODUCTION IN PART OR WHOLE IS STRICTLY PROHIBITED WITHOUT WRITTEN PERMISSION.
PROPRIETARY
Regulator
+5V
U1
+3.3V
VIN VOUT
EN GND
AP2112K_3.3V
C1 1uF
C2 1uF
GND
Mounting Holes
H1 H2
LEDS
PB5/MOSI
R2 10K
D2 Red
GND
VCC
R1 10K
D1 Red
Reset
S1
PB0/PF2-NRST
Microswitch
Microcontoller
IC1
VCC
PA0/MISO
PA1/SCK
PA2/CS
PB5
PA14
PA13
PB0/PF2
VSS/EP
PA14(SWCLK)/PB6(SCL)
PA13(SWDIO)/PA10(SDA)
PY32F003L24D6TR
Voltage Selector
JP1
PINHD-1X31X3_SILKSCREEN
Level Shifters
Q1 2N7002KDW
SWDIO/SDA
SWCLK/SCL
RN1 10K
Q2 2N7002KDW
MOSI
MISO
RN2 10K
SCK
CS
Q3 2N7002KDW
RN3 10K
GPIOS
J1
1X5_PIN_HEADER_2.54MM
J2
J3
J4
J5
SHIELD
S1*2
Title: UE0102 - PY32F003L24D6TR DevLab v6
SKU: UE102
REV: 1

9.2 Port A – Multiplexing Function Mapping (AF0–AF15)

	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
PA0	–	USART1_CTS	–	–	USART2_CTS	–	–	COMP1_OUT	–	USART2_TX	SPI1_MISO	–	–	TIM1_CH3	TIM1_CH1N	IR_OUT
PA1	SPI1_SCK	USART1_RTS	–	–	USART2_RTS	–	–	EVENTOUT	–	USART2_RX	SPI1_MOSI	–	–	TIM1_CH4	TIM1_CH2N	MCO
PA2	SPI1_MOSI	USART1_TX	–	–	USART2_TX	–	–	COMP2_OUT	–	–	SPI1_SCK	–	I2C_SDA	TIM3_CH1	–	–
PA10	–	USART1_RX	TIM1_CH3	–	USART2_RX	TIM17_BKIN	I2C_SDA	EVENTOUT	USART1_TX	–	SPI1_NSS	–	I2C_SCL	–	–	–
PA13	SWDIO	IR_OUT	–	–	–	–	–	EVENTOUT	USART1_RX	–	SPI1_MISO	–	–	TIM1_CH2	–	MCO
PA14	SWCLK	USART1_TX	–	–	USART2_TX	–	–	EVENTOUT	–	–	–	–	–	–	–	MCO

Port B – Horizontal

	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
PB0	SPI1_NSS	TIM3_CH3	TIM1_CH2N	–	–	EVENTOUT	–	COMP1_OUT	–	–	–	–	–	–	–	–
PB5	SPI1_MOSI	TIM3_CH2	TIM16_BKIN	USART1_CK	USART2_CK	LPTIM_IN1	–	COMP1_OUT	–	–	–	–	–	–	–	–
PB6	USART1_TX	TIM1_CH3	TIM16_CH1N	–	USART2_TX	LPTIM_ETR	I2C_SCL	EVENTOUT	–	–	–	–	–	–	–	–

PF2 / NRST – Horizontal

	AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
PF2-NRST	–	–	–	–	USART2_RX	–	MCO	–	–	–	–	–	–	–	–	–