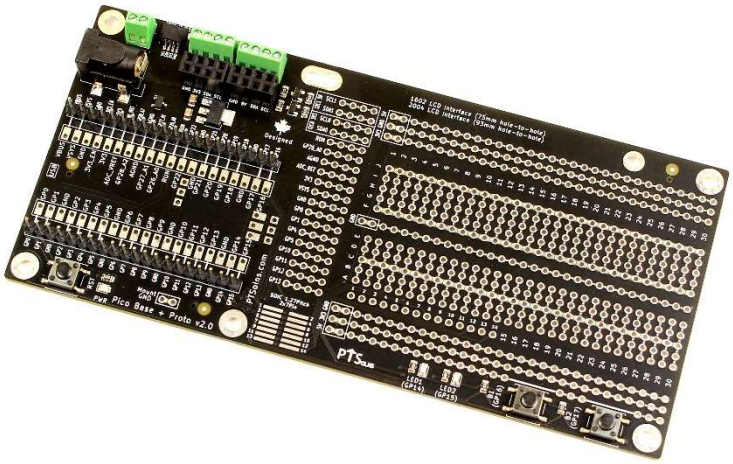
Pico Base + Proto

1 DESCRIPTION



The PTSolns *Pico Base + Proto* is intended to interface with the Raspberry Pi Pico (henceforth referred to as Pico) offering much convenience. The left side of the board consists of the *Pico Base*, while the right side of the board consists of a prototyping section packed with features. These features are designed to provide the most flexibility to the user for realizing their circuit design.

While mounted in the *Pico Base + Proto*, the Pico can be powered in multiple ways. Onboard protection prevents current from going into a battery (if connected via the female jack or the 2-pin screw terminal) while power is supplied by the onboard Pico USB connection. The user can switch between power sources without interrupting their circuit or the Pico. The board also offers a reset button as well as a power LED.

An onboard logic level shifter allows for the simultaneous operation of both 3.3V as well as 5V I2C peripherals. Suitably located adjacent to the 5V I2C connectors, the 1602 and 2004 LCD mounting interface lets the user easily add an LCD to their project.

The *Pico Base + Proto* has two programmable buttons and two programmable LEDs. The prototyping section has three power rails at the top, one at the center, and another three at the bottom. These rails can be configured for multiple uses and by default are not connected to 3.3V, 5V, and GND. The user can solder the corresponding jumper pads to electrically connect the rails to 3.3V, 5V, and GND. The prototyping section consists of electrically connected rows-of-five through holes, laid out in a traditional breadboard pattern, with a total of 300 tie-points. Three unique rows made up of teardrop-shaped soldering pads allow the user to easily connect adjacent rows-of-five. The onboard SOIC interface has a breakout running immediately adjacent to the prototyping section.

For tutorials and example sketches using the *Pico Base + Proto*, the user is referred to:
https://github.com/PTSolns/PTSolns_PicoBase

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2 DOCUMENT REVISION HISTORY

Current document revision is Rev 0.

3 PRODUCT FEATURES

This section highlights the features of the *Pico Base + Proto*. The features outlined in Section 3.1 to Section 3.9 relate to, and are in common with, the *Pico Base*. For full detail of the *Pico Base*, the user is referred to the corresponding datasheet *"Datasheet_PTSolns_PicoBase_RevX.pdf".* The features discussed in Section 3.10 to 3.15 relate to the *+ Proto* part of the *Pico Base + Proto*.

3.1 Power Input (*Pico Base*)

The *Pico Base + Proto* has the following power input options:

1a) 2-Pin screw terminal (2.54 mm/0.1 in). V_{in} = 3.0V to 12V, or 6.2V to 12V if using 5V.
1b) Female barrel jack (2.1 mm X 5.5 mm). V_{in} = 3.0V to 12V, or 6.2V to 12V if using 5V.
2) Onboard USB via Pico.

These power input options are shown in Figure 1. Note that the positive terminal of Option 1a is electrically connected to the positive terminal of Option 1b. The negative terminal of Option 1a is electrically connected to the negative terminal of Option 1b. **It is not recommended to use both power input Options 1a and 1b simultaneously.**

The board can also be powered by the Pico itself via the onboard USB port. Whenever either Option 1a or 1b is plugged in and Option 2, the USB power (Option 2) takes priority. In other words, if 5V is supplied by the onboard USB via the Pico, the power supply of Options 1a and 1b are disconnected by onboard protection. The user can switch between powering the board via Options 1a/1b and Option 2 without power interruption to any part of the *Pico Base + Proto*. This gives the user the flexibility of programming the Pico via USB connection to their computer, and without power interruption connect an external battery via Options 1a/1b.

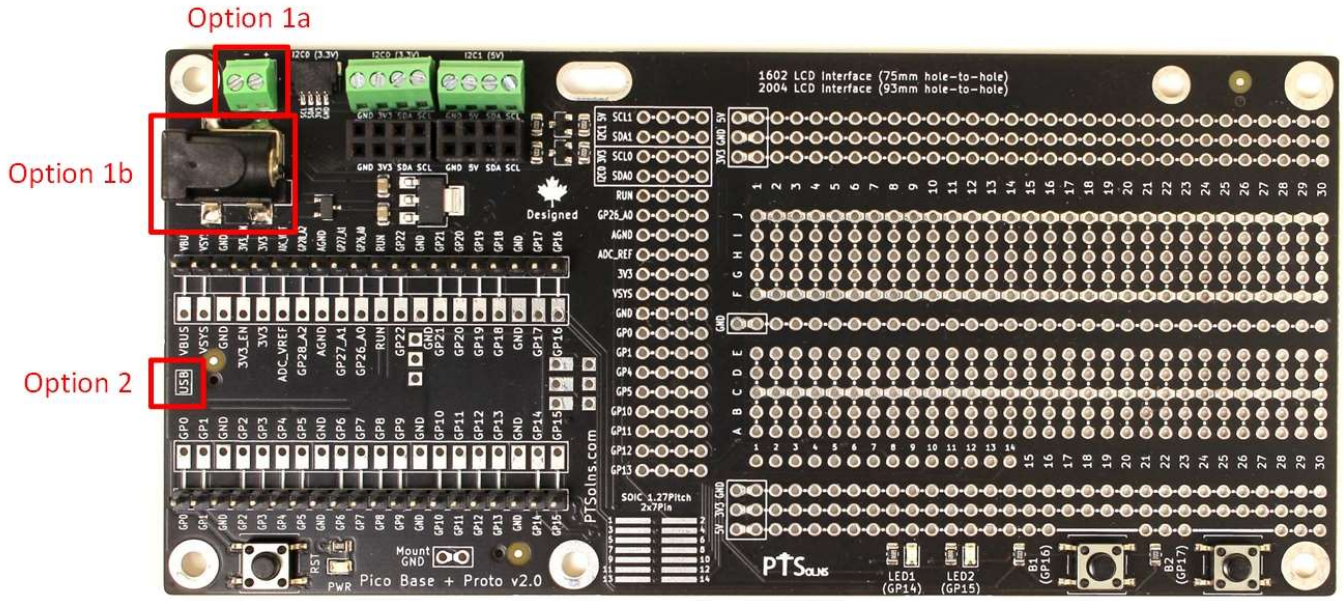

Figure 1: Two power input options for the Pico Base + Proto. Note that for Option 2 the Pico is not shown where the USB would be connected.

3.2 I2C (*Pico Base*)

The Pico inherently contains two I2C ports (Port 0 and Port 1), with various respective pins a user can implement. The *Pico Base + Proto* takes advantage of this and hardwires pins GP20 and GP21 to be used for 3.3V I2C devices over Port 0. Furthermore, onboard is a 2-channel 3.3V-to-5V logic level shifter (LLS) that takes the hardwired pins GP18 and GP19 and shifts their voltage to 5V. For the 5V I2C arrangement over Port 1, note that the SCL and SDA bus is not directly connected to the pins GP19 and GP18 on the Pico directly, but rather indirectly through the LLS. With this arrangement the user can connect 3.3V I2C devices on Port 0 and simultaneously connect 5V devices over Port 1. If powering the board via the external input (Options 1a/b outlined in Section 3.1), then the 5V I2C port only functions properly if the user supplies an input voltage of at least 6.2V[1]. If powering the board via the onboard USB port on the Pico (Option 2 outlined in Section 3.1), then 5V is sufficient for the Port 1 I2C at 5V.

The I2C ports have multiple breakouts. Both the 3.3V Port 0 I2C as well as the 5V Port 1 I2C each have a screw terminal connector, a 2x4 pin female header connector and 4-pin breakout rows. The user can connect their I2C peripherals on any of these connector breakouts. Furthermore, the 3.3V Port 0 I2C contains an addition 1mm 4-pin JST connector, commonly called a QWIIC® connector. Credit should be given to Sparkfun for developing and popularizing the QWIIC® Connect System. For more information the user is referred to https://www.sparkfun.com/qwiic.

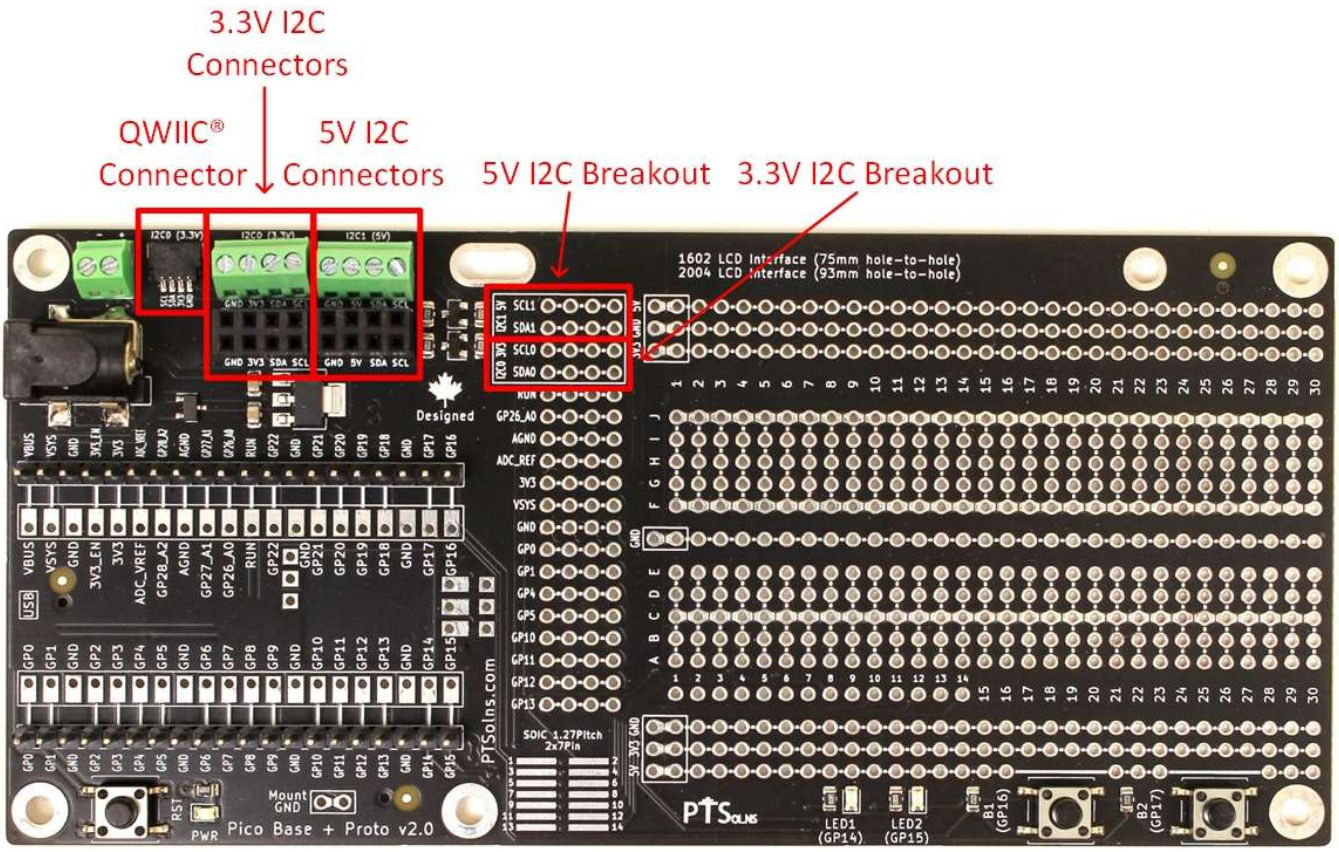

Figure 2: 3.3V and 4V I2C connectors on the Pico Base + Proto.

[1] 6.2V = 5V + $V_{dropout}$, where $V_{dropout}$ = 1.2V @ 1A output current.

3.3 Pico Soldering Pads (*Pico Base*)

Typically, the Pico does not have headers (usually male headers) soldered to the board. Due to this, the *Pico Base + Proto* does not have the matching headers (usually female heads) soldered on the footprint where the Pico is intended to be placed, as shown in Figure 3. This gives the user multiple configuration options as to how to connect the Pico to the *Pico Base + Proto*. Since the soldering pads are a stretched oval shape, the user can solder the Pico right onto the board. This establishes a permanent connection, and the Pico is not easily removed. If the user wants to be able to remove the Pico from the board, it is suggested that they use matching male and female headers. In most cases male headers are soldered onto the Pico, and female headers onto the *Pico Base + Proto*.

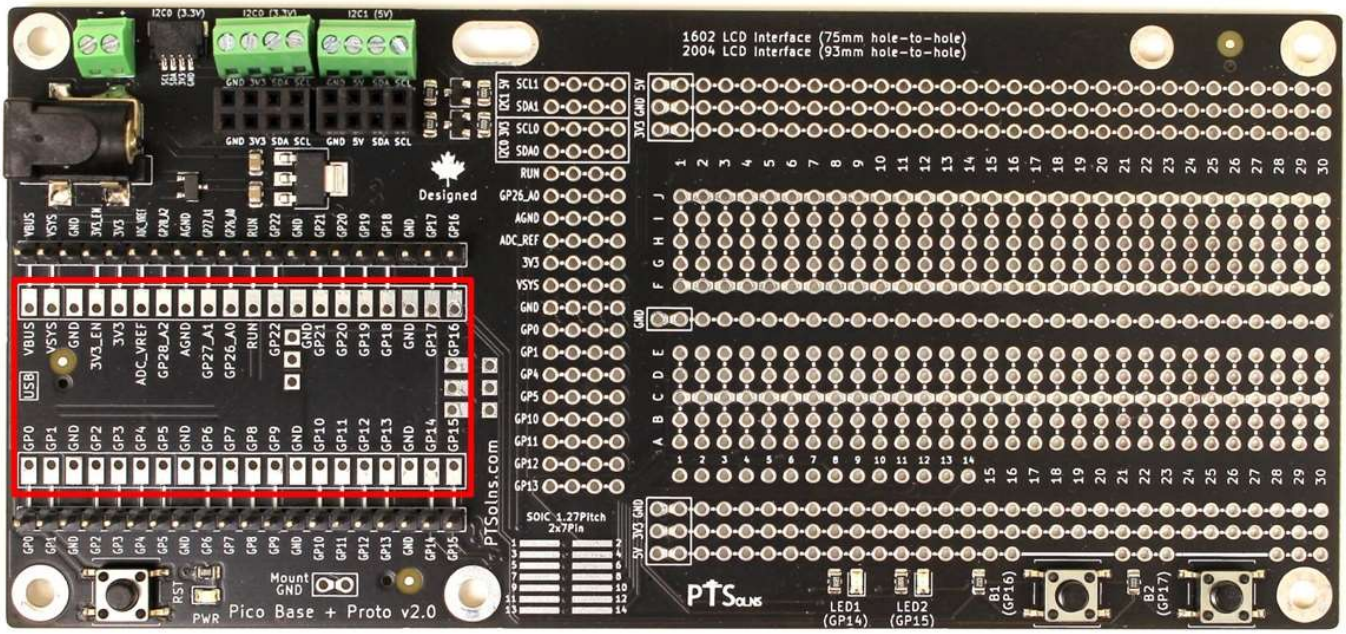

Figure 3: Soldering Pads for Pico on the Pico Base + Proto.

3.4 Pico Pins Breakout (*Pico Base*)

Adjacent to the Pico soldering pads are single rows of male headers, one on either side of the Pico, as shown in Figure 4. These breakout pins give convenient access to all the pins on the Pico. **Since all the pins are exposed, the user should take caution not to accidently short circuit any of the pins.**

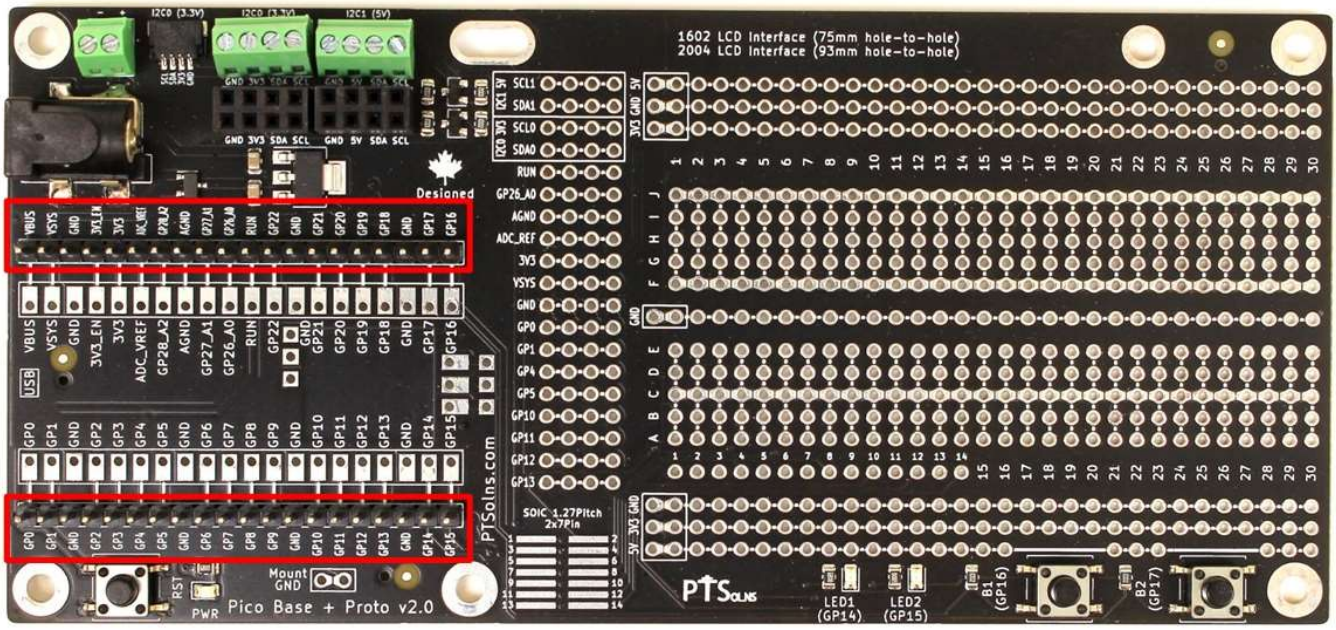

Figure 4: Male header single row breakout pins on either side of the Pico.

3.5 Debugging Pins Breakout (*Pico Base*)

Different Pico versions have two locations on the board where the debugging pins are made available. The *Pico Base + Proto* is compatible with all the versions of the Pico (Pico, Pico W, Pico H, Pico WH), such that any of the Pico versions can be used to access the debugging pins on the board. This is shown in Figure 5.

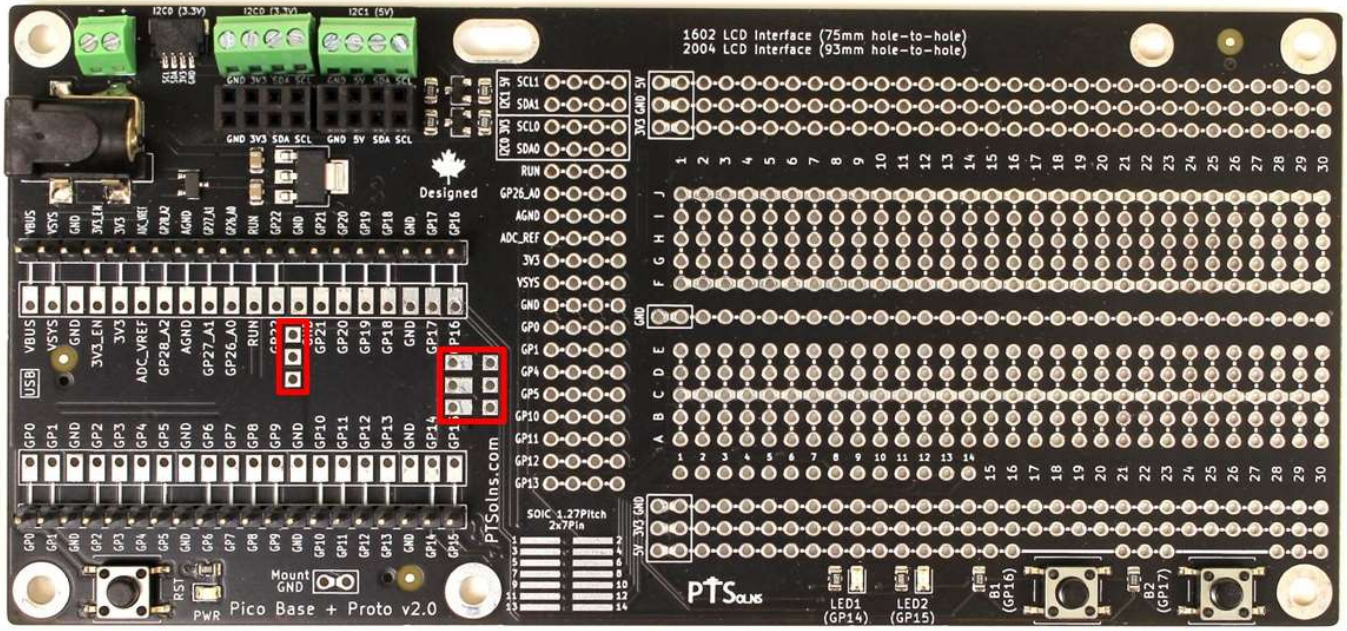

Figure 5: Debugging pins available on the Pico Base + Proto.

3.6 Reset Button (*Pico Base*)

A reset button is present near the bottom right of the *Pico Base + Proto*, which when pressed pulls the RUN pin on the Pico to GND. The reset button is labelled “RST” as shown in Figure 6.

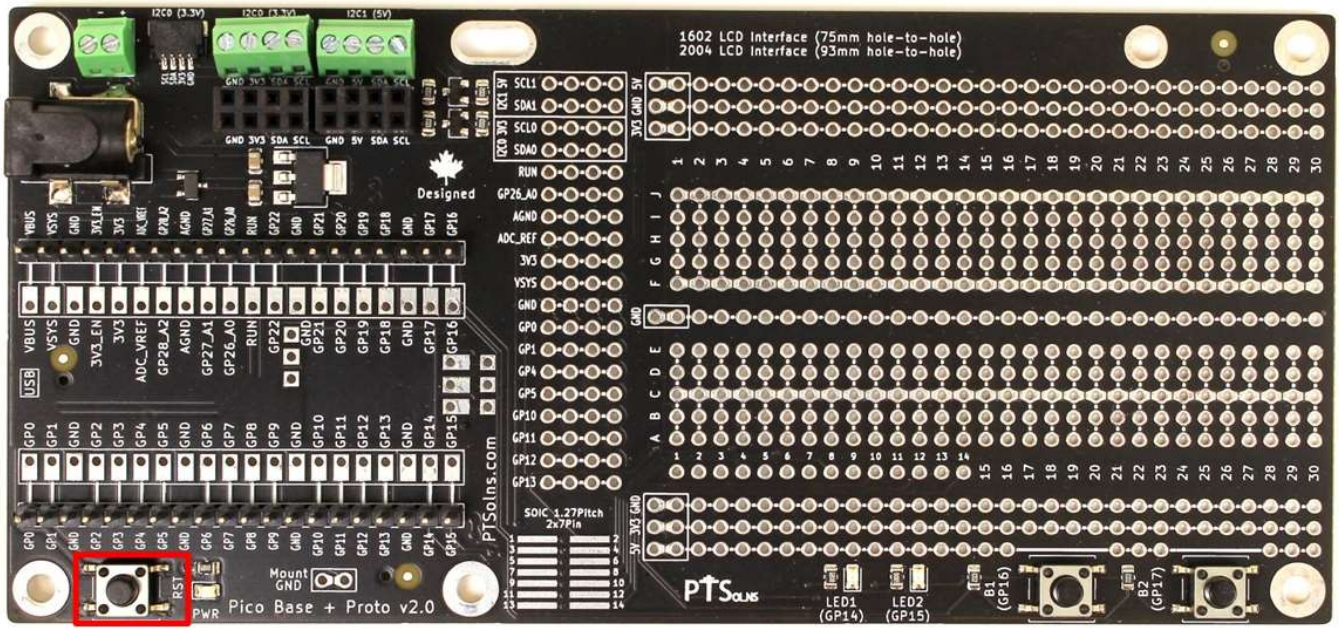

Figure 6: Reset button “RST” on the Pico Base + Proto.

3.7 Power LED (*Pico Base*)

If the *Pico Base + Proto* is powered via any of the options as outlined in Section 3.1, a red LED turns on. This power LED is labelled “PWR” as shown in Figure 7.

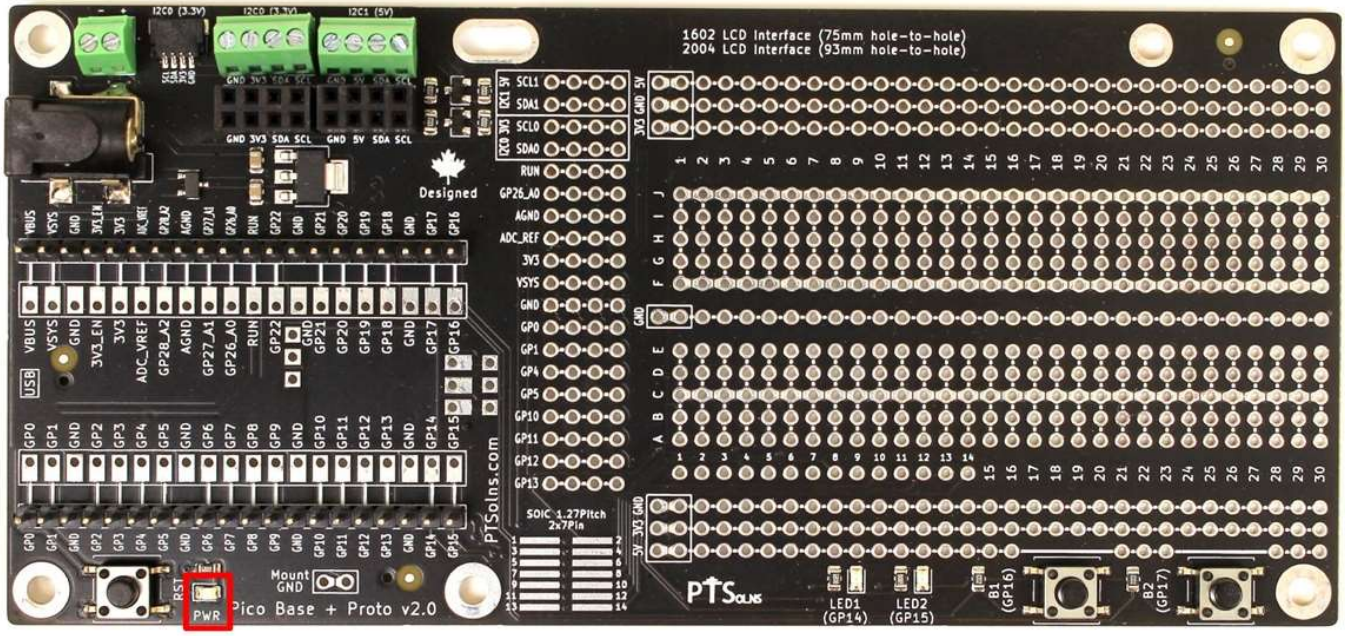

Figure 7: Power LED PWR on the Pico Base + Proto.

3.8 Silkscreen Printing (*Pico Base*)

For convenience, most of the silkscreen printing is done on both sides of the *Pico Base + Proto*. The breakout section of the *Pico Base + Proto* is fully labelled along the rows and columns. White dashed silkscreen lines between tie-points indicate an existing hardwired electrical connection.

3.9 Mark of Authenticity (*Pico Base*)

Authentic PTSolns PCBs have a black solder mask color and are marked with the “PTSolns” logo in white silkscreen printing. The “Canadian Designed” symbol, consisting of the Canadian Maple Leaf with the word “Designed” underneath, can also be found on the PCB in white silkscreen printing. The “PTSolns” trademark and the “Canadian Designed” symbols are shown in Figure 8.

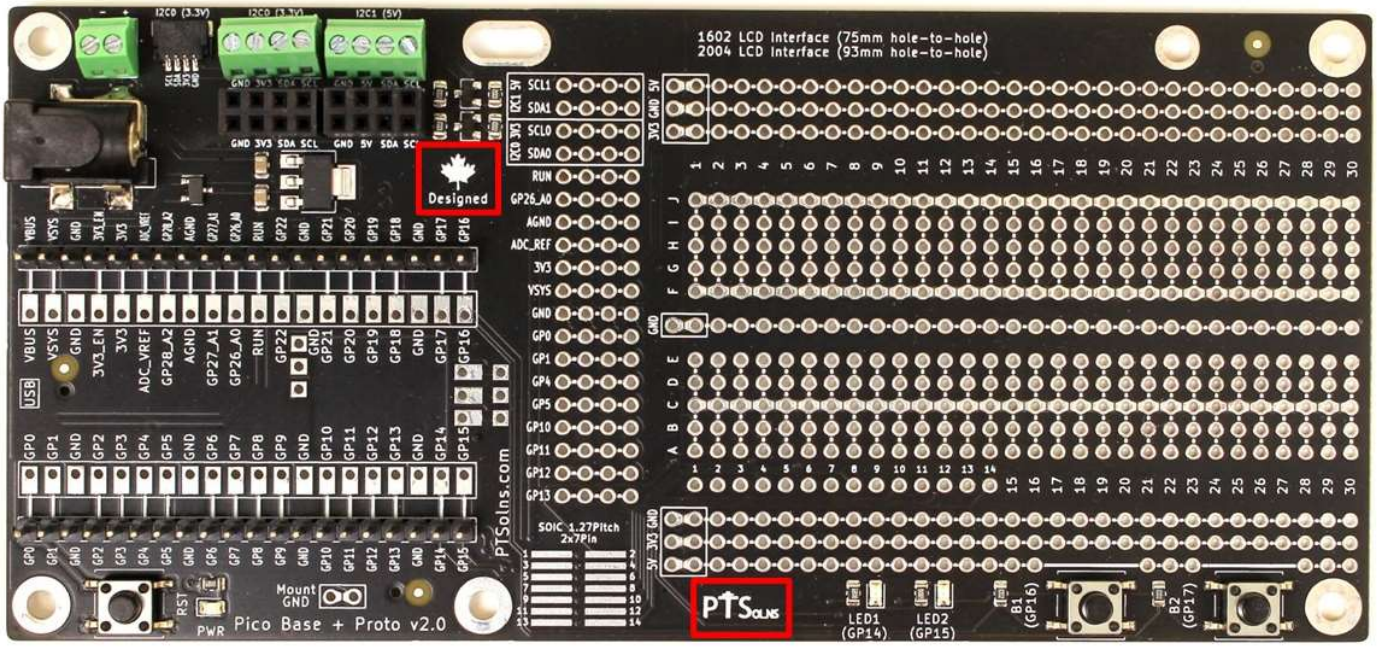

Figure 8: The "Canadian Designed" symbol found on authentic PTSolns PCBs.

3.10 Prototyping Section (*Pico Base + Proto*)

The right side of the *Pico Base + Proto* contains the prototyping section of the board. The prototyping section resembles a traditional breadboard layout in that there are two divided sections. Each section (columns A to E, and columns F to J) contains electrically connected rows-of-five pins, spaced 2.54mm/0.1in apart. The electrical connections are indicated by dashed white silkscreen printing. Each of the sections is 30 rows long, and hence consist of 150 pins each, or a total of 300 pins for the entire prototyping section.

There are special columns running left-to-right along all 30 rows of both sections. These special columns are made up of teardrop-shaped soldering jumper pads and can be bridged with a small amount of solder. This allows users to electrically connect adjacent rows-of-five. The bottom section has a single special column along the C column. The top section has two special columns along the F and J columns. This is shown in Figure 9.

The prototyping section contains a total of seven configurable rails. By default, these rails are electrically isolated from the rest of the board. There are three rails (5V, 3.3V, and GND) above the prototyping section. There are another three rails (GND, 3.3V, and 5V) below the prototyping section. There is a single rail (GND) at the center, dividing the prototyping section into two.

Finally, note that the bottom most rail (5V) is missing some through-holes. This was done out of necessity in order to accommodate the nearby programmable buttons. Nevertheless, the entire rail is electrical connected from row 1 to row 30.

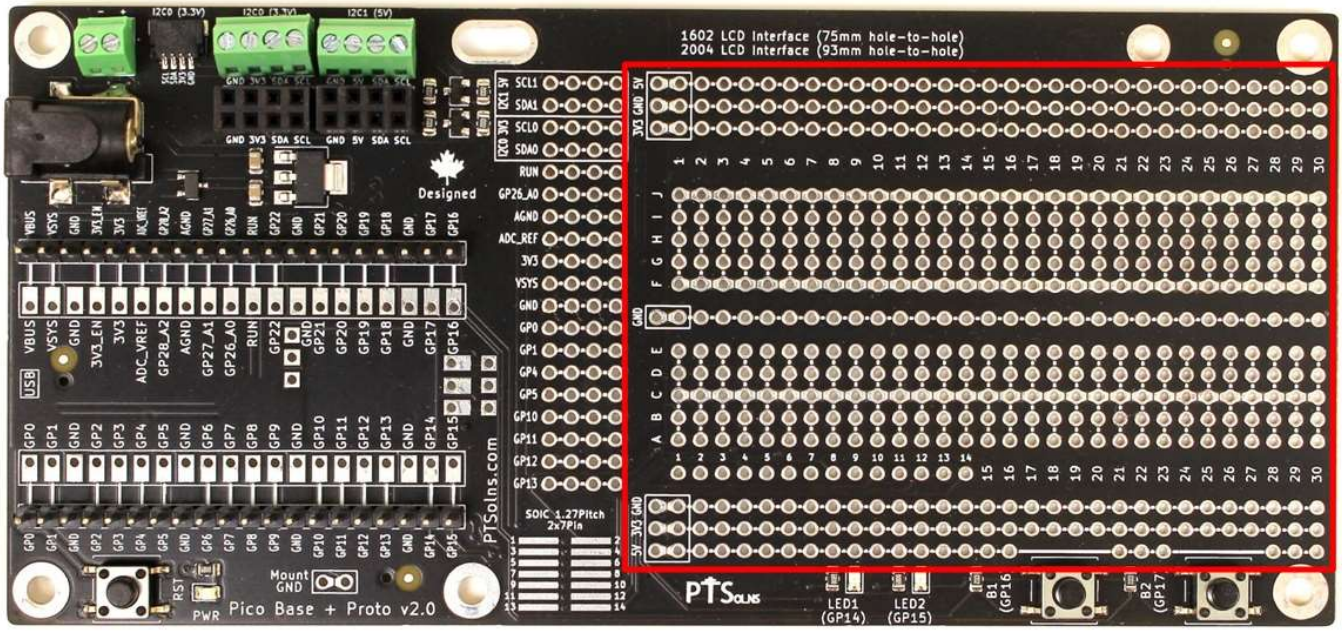

Figure 9: Prototyping section of the Pico Base + Proto.

3.11 Programmable LEDs (*Pico Base + Proto*)

There are two separately programmable red LEDs along the bottom edge of the *Pico Base + Proto*, as shown in Figure 10. The leftmost LED, labelled LED1, is connected to Pico pin GP14. The rightmost LED, labelled LED2, is connected to Pico pin GP15.

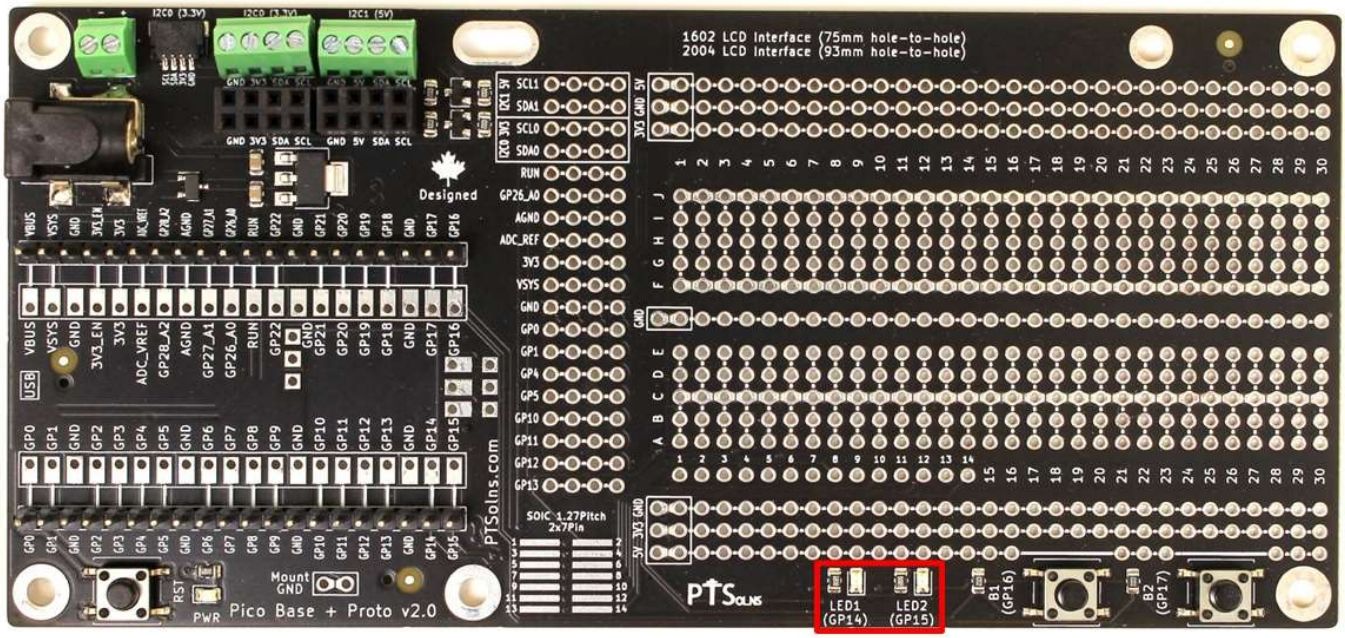

Figure 10: Programmable LEDs on the Pico Base + Proto.

3.12 Programmable Buttons (*Pico Base + Proto*)

There are two separately programmable buttons along the bottom edge of the *Pico Base + Proto*, as shown in Figure 11. The leftmost button, labelled B1, is connected to Pico pin GP16. The rightmost button, labelled B2, is connected to Pico pin GP17.

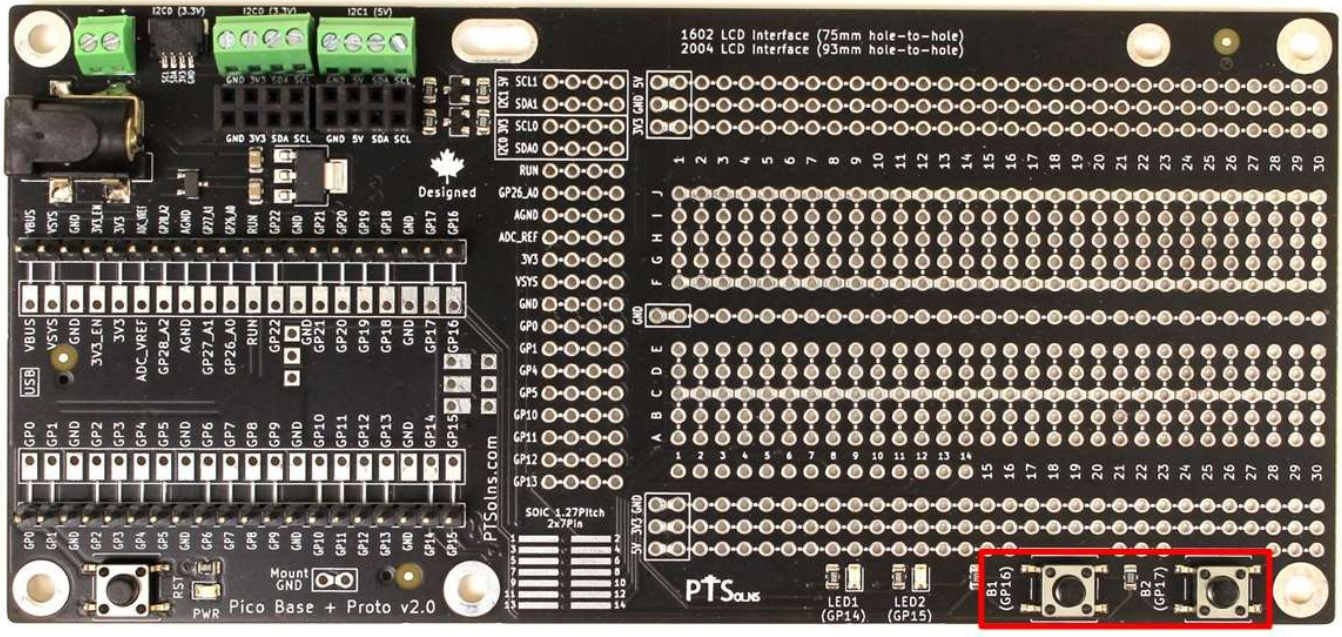

Figure 11: Programmable buttons on the Pico Base + Proto.

3.13 Pico Pins Rows-Of-Four Breakout (*Pico Base + Proto*)

Some of the most important pins of the Pico are further broken out in rows-of-four near the centre of the *Pico Base + Proto*, as shown in Figure 12. This breakout section includes the following pins of the Pico (top to bottom):

- GP19 (Labelled as SCL1. Shifted up to 5V. (See Section 3.2)
- GP18 (Labelled as SDA1. Shifted up to 5V. (See Section 3.2)
- GP21 (Labelled as SCL0)
- GP20 (Labelled as SDA0)
- RUN
- GP26_A0
- AGND
- ADC_REF
- 3V3
- VSYS
- GND
- GP0
- GP1
- GP4
- GP5
- GP10
- GP11
- GP12
- GP13

Note that the first two of these breakout rows (SCL1, SDA1) are not directly connected to the Pico, but rather to the 5V side of the onboard logic level shifter (LLS). The corresponding pins on the Pico are connected on the 3.3V side of the LLS. The details of the LLS as they relate to I2C on 5V are discussed in Section 3.2.

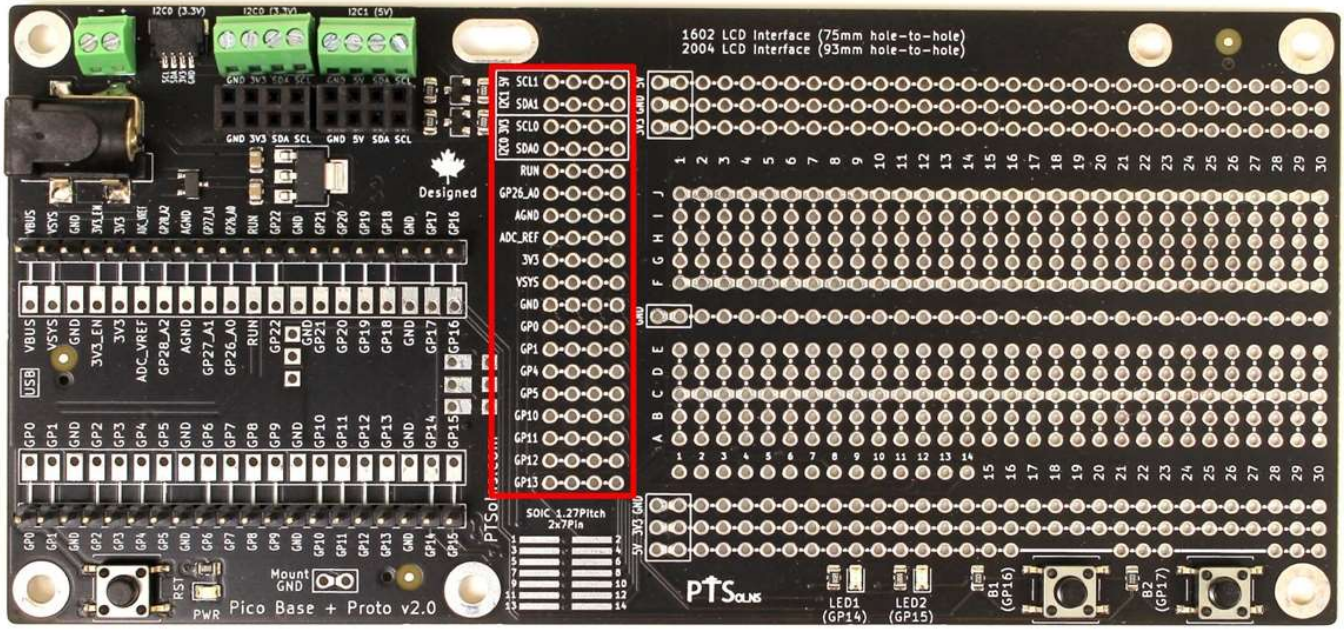

Figure 12: Rows-of-four breakout of important pins on the Pico.

3.14 SOIC Interface (*Pico Base + Proto*)

Near the center bottom of the *Pico Base + Proto* is a 2x7 pin SOIC footprint with a pitch of 1.27mm, as shown in Figure 13. Each pin of the SOIC footprint has a breakout pin located close to the main prototyping section of the board. This interface allows for easy testing of surface mount ICs by having the pins of the ICs close to the prototyping section that can contain the rest of the circuit.

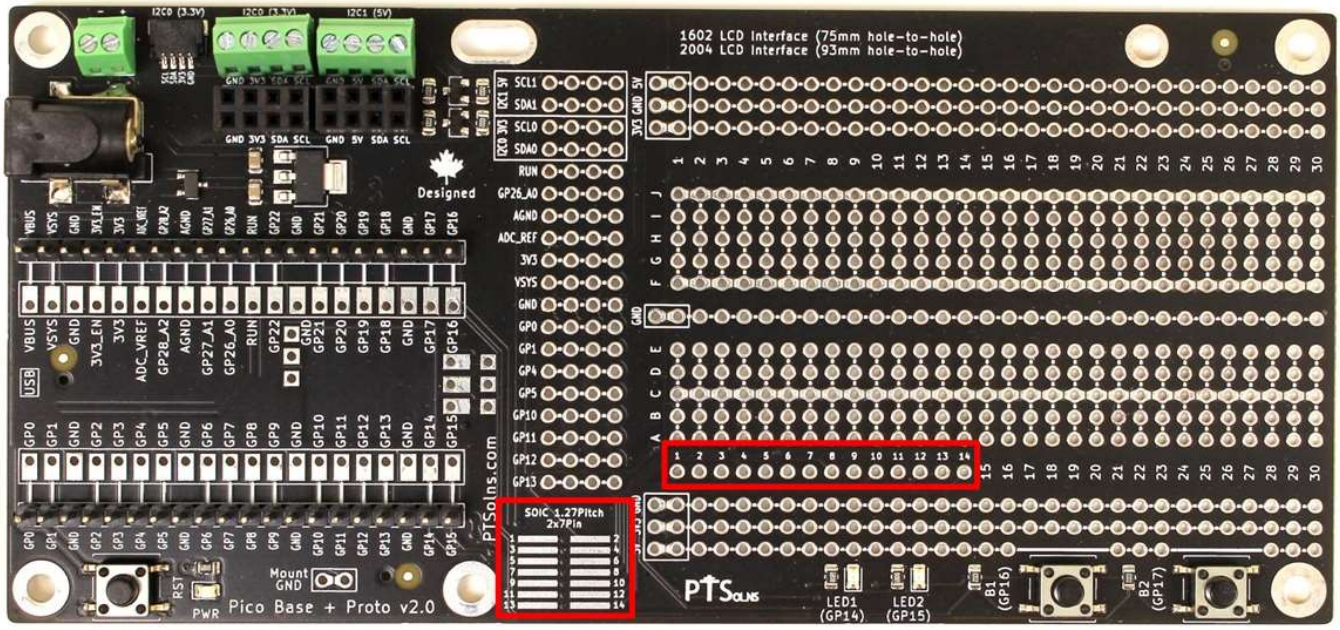

Figure 13: SOIC footprint on the Pico Base + Proto.

3.15 Mounting Holes (*Pico Base + Proto*)

There are a total of seven mounting holes on the *Pico Base + Proto*. Some of these mounting holes serve multiple purposes. The four mounting holes located at each of the corners of the boards (labelled in Figure 14 as 1, 2, 3, and 4) are intended to mount the board itself to a sturdy surface or enclosure. Mounting hole number 4 also servers as the right mounting hole intended for an LCD. Along with mounting hole 5 and 6, these three mounting holes can support the common 1602 and 2004 LCDs. Finally, mounting holes 6 and 7 are present to align with the mounting holes of the *Pico Base*.

All the mounting holes 1-7 are electrically connected to each other, and by default isolated from the rest of the board. The user can ground these mounting holes by bridging the solder jumper pads as shown in Figure 14.

For dimensions of the mounting holes see Figure 15 - Figure 17.

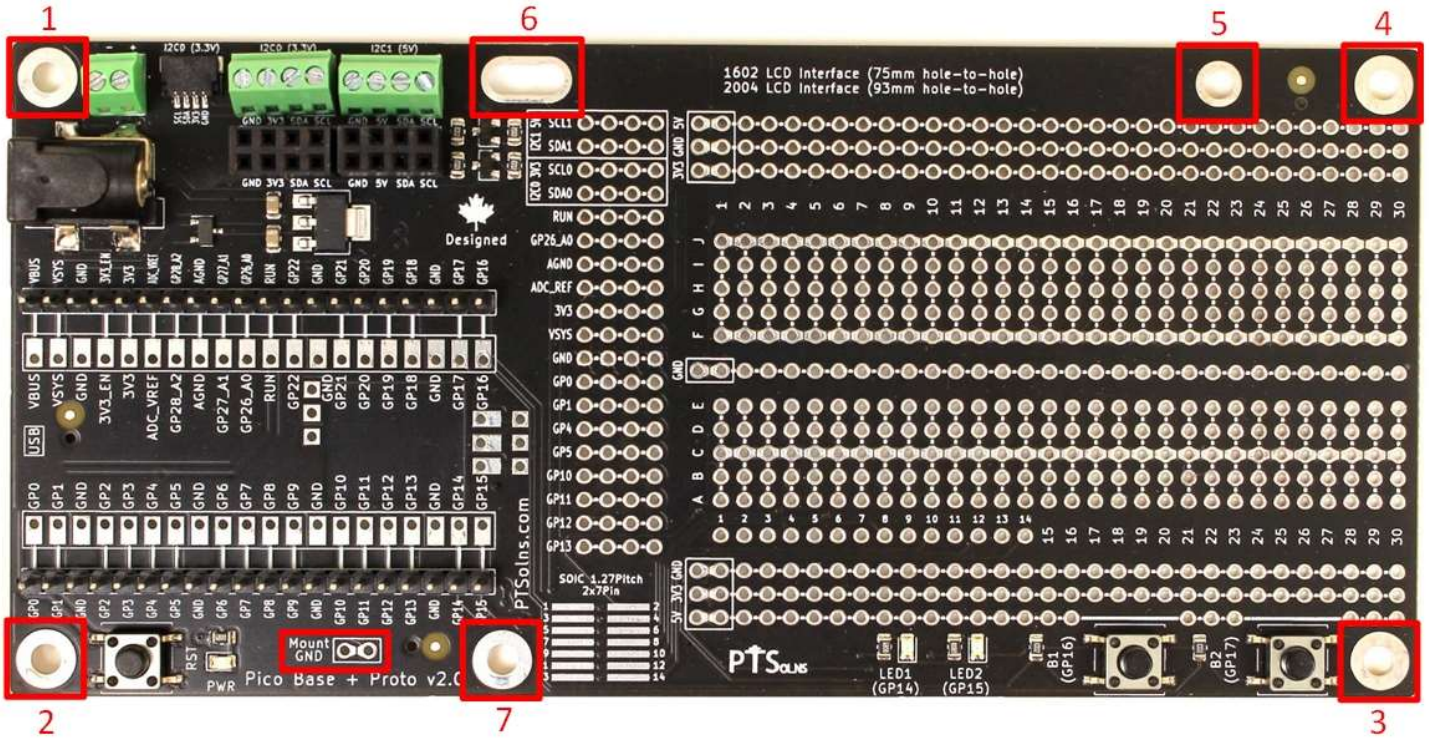

Figure 14: Mounting holes on the Pico Base + Proto.

4 PHYSICAL PROPERTIES

The physical properties of the *Pico Base + Proto* are outlined in Table 1.

Table 1: Physical Properties.

	Quantity	Value	Reference
PCB	Length	152.5 mm	Figure 15
	Width	70.6 mm	Figure 15
	Thickness	1.6 mm	Figure 15
	Corner radius	1.0 mm	Figure 15
	Weight	48 g	--
	Color	Black	--
	Silkscreen	White	--
Tie-point	Number of tie-points in prototyping section	300	Figure 15
	Tie point spacing	2.54 mm/0.1 in	Figure 15
	Tie-point hole diameter	1.0 mm	Figure 16
	Tie-point copper pad diameter	1.7 mm	Figure 16
Mounting	Corner mounting hole diameter	3.2 mm	Figure 16
	Corner mounting copper pad diameter	6.4 mm	Figure 16
	Corner mounting hole center-to-center distance along length	144.5 mm	Figure 15
	Corner mounting hole center-to-center distance along width	62.6 mm	Figure 15
	Corner mounting hole to middle mounting hole center-to-center short distance	49.1 mm	Figure 15
	2004 LCD mounting hole center-to-center (left hole stretched)	93mm	Figure 17
	1602 LCD mounting hole center-to-center (left hole stretched)	75mm	Figure 17
Material	Lead free HASL-RoHS surface finish		--
	FR-4 base		--

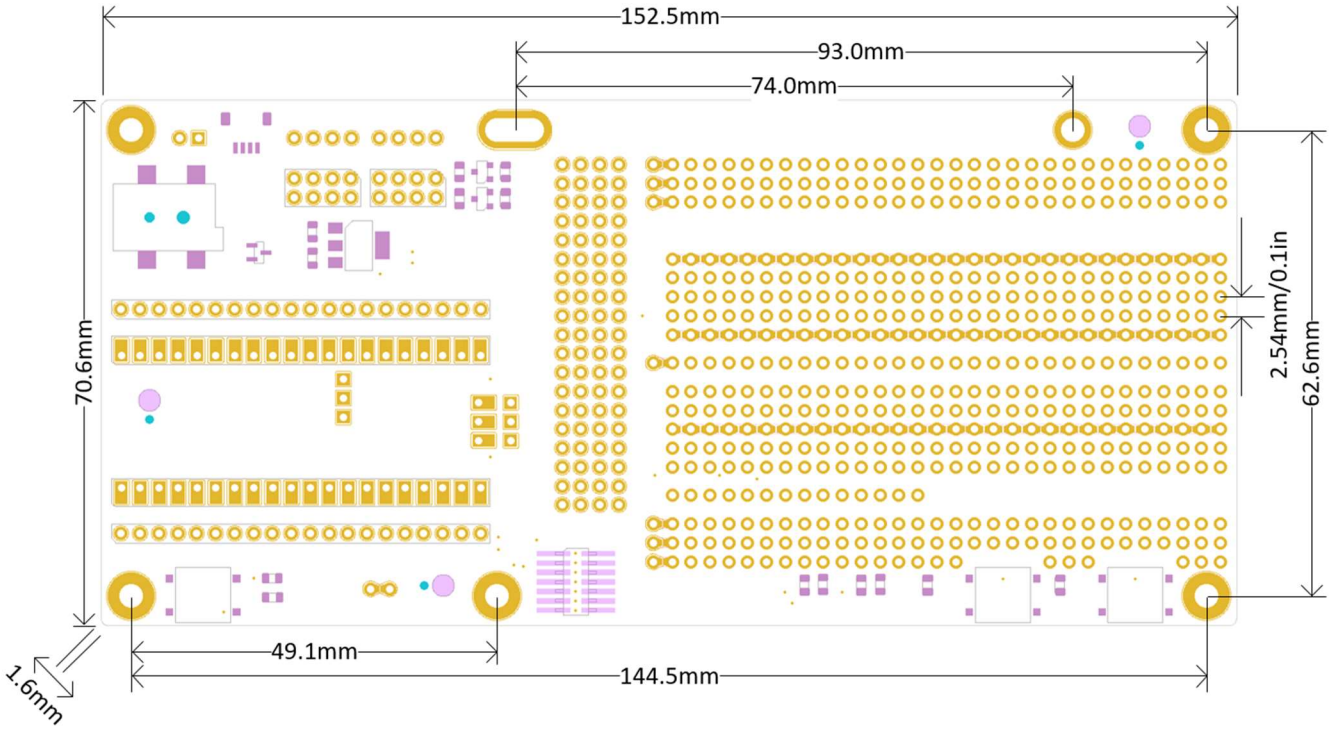

Figure 15: Dimensions of the Pico Base + Proto PCB.

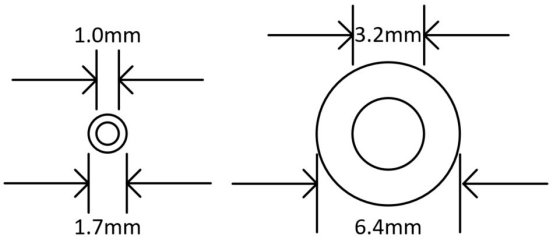

Figure 16: Dimensions of tie-point (left) and corner mounting hole (right).

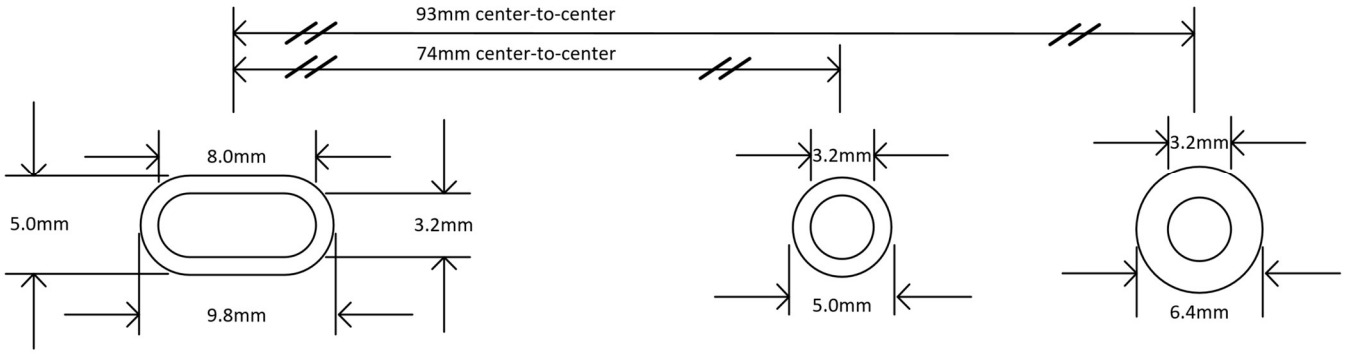

Figure 17: Dimensions of the LCD 1602 and 2004 interface.

5 ELECTRICAL PROPERTIES

The Pico has a minimum acceptable input voltage of 1.8V (see Pico datasheet for more details). However, if powering the *Pico Base + Proto* via the external Options 1a/b (outlined in Section 3.1), then an additional 1.2V to cover the dropout voltage of the onboard linear voltage regulator is required. Therefore, it is recommended that the input voltage is at least 3.0V if the user only intents to use 3.3V in their project. However, for the same reason that an additional 1.2V is needed for the regulator, the 5V and Port 1 I2C bus will not function properly unless a minimum of 6.2V is supplied.

Note that the above input voltage requirements only apply if powering the board with Options 1a/b. If powering the board via the onboard USB on the Pico (Option 2), then the 5V supplied by the USB is sufficient to operate everything on the board. This is because when the USB on the Pico is plugged in, the linear voltage regulator is bypassed and therefore there is no dropout voltage to overcome.

Electrical properties are outlined in Table 2. Electrical connections made by copper traces are shown in Figure 18. Copper traces have a weight of 1 oz/ft^2.

Table 2: Electrical Properties.

Quantity	Value
Input voltage (Option 1a/b outlined in Section 3.1)	3.0V – 12V, is only using 3.3V (6.2V – 12V, if using 5V)
Current rating (Prototyping section, 3.3V and 5V lines/breakout)	1A (The 3.3V regulator onboard the Pico as a lower rating, see the Pico datasheet)

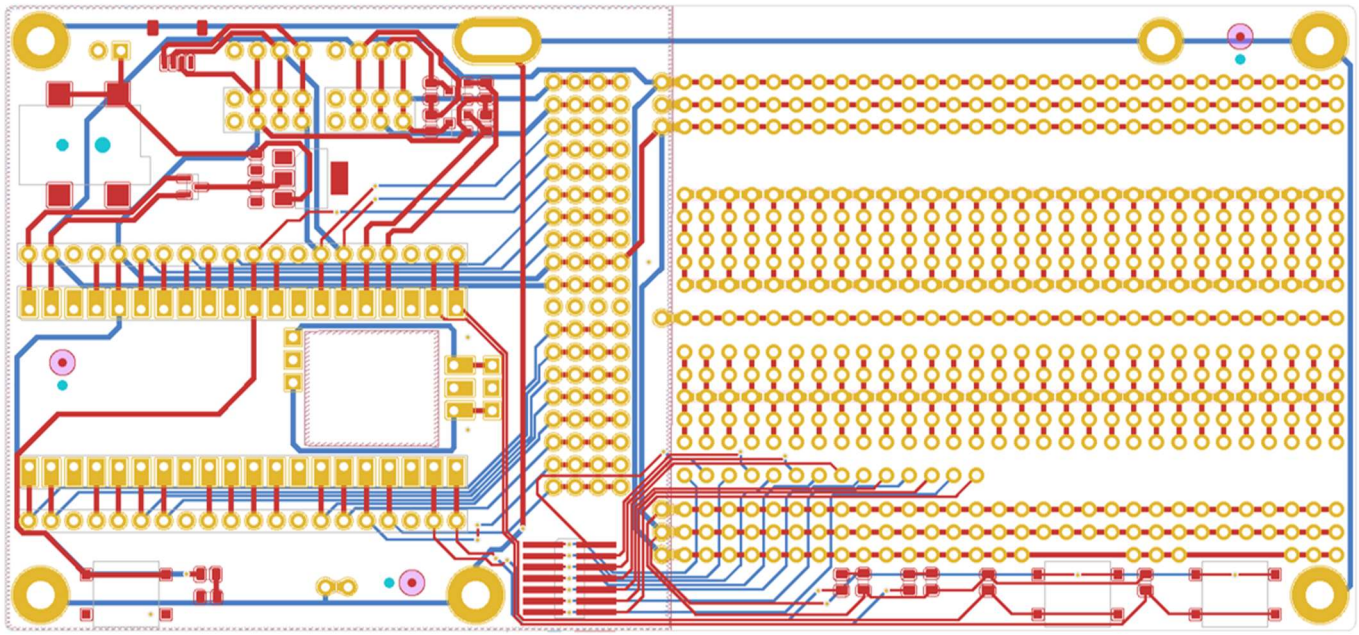

Figure 18: Electrical connections of the Pico Base + Proto.

6 EXAMPLE APPLICATION

This section presents one of many possible example applications of the *Pico Base + Proto*. Arduino IDE example sketches demonstrating features such as how to program the buttons or LEDs, how to use 3.3V and 5V devices simultaneously, and others can be found on: https://github.com/PTSolns/PTSolns_PicoBase

6.1 3.3V I2C Peripheral Displaying on 5V I2C LCD

This example application shows how physically connect two different peripherals to the Pico using the *Pico Base + Proto*. As can be seen in Figure 19, a module is plugged into the QWIIC® connector, which gathers temperature and humidity sensor data. This module can be many different types, however in this case it is the Sparkfun Atmospheric Sensor BME280, which is not shown in the image. This BME280 module communicates over 3.3V I2C and could also be connected to the adjacent screw terminal of female header breakout, depending on how the wires are terminated.

Also seen in Figure 19 is a 2004 LCD, which is mounted to the board and connected to the 5V I2C port. This is possible as the LCD has the "I2C backpack" soldered to the back of the module. The user is reminded that only LCDs with this I2C backpack can be connected directly to the 5V I2C port on the board. It is however possible to connect an LCD to the board without the I2C backpack by using the breakout and prototyping sections.

In this example, the Pico is coded using the Arduino IDE. The full sketch is not provided here but can be found on: https://github.com/PTSolns/PTSolns_PicoBase/tree/main/examples/I2C0_3V3_and_I2C1_5V

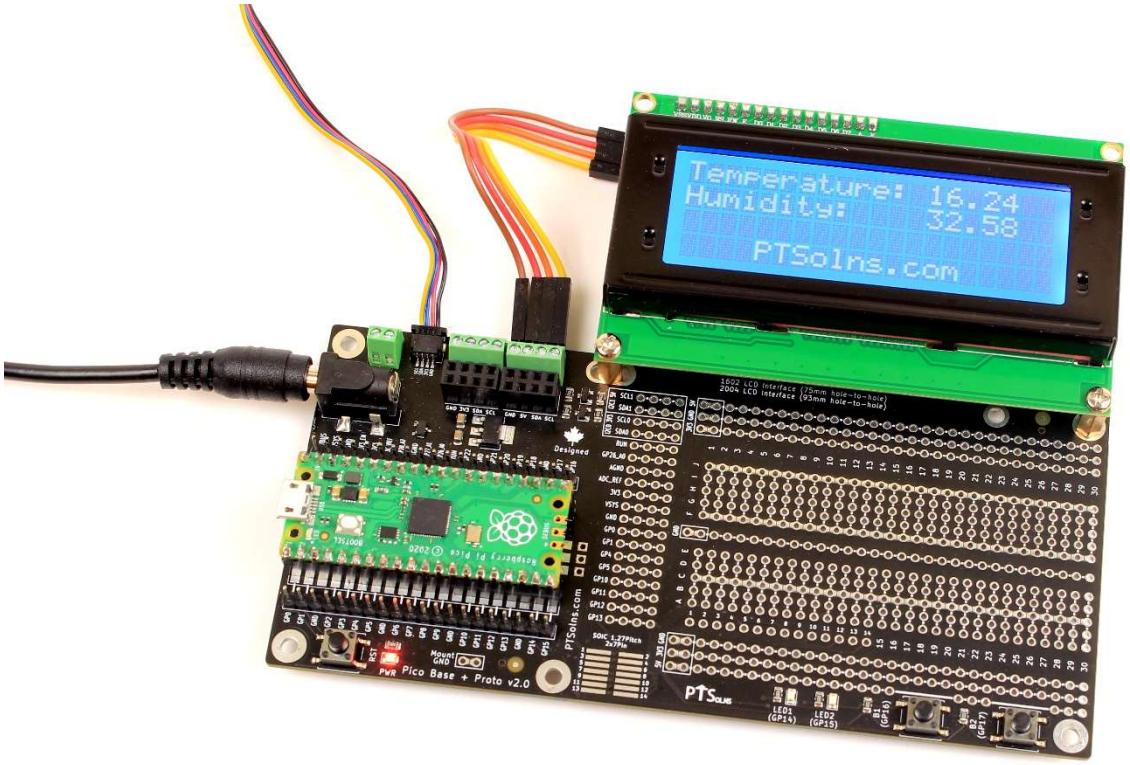

Figure 19: Example application of 3.3V I2C peripheral displaying on 5V I2C LCD.

It is important to note that the *Pico Base + Proto* hardwires the Pico pins for the Port 0 (3.3V I2C) and Port 1 (5V I2C). There are many pins available on the Pico to connect I2C devices. However, in order to provide the I2C interface on the board particular pins were chosen and fixed. These pins must be defined in the Arduino IDE sketch and cannot be changed.

The 3.3V I2C pins are hardwired to the Pico pins as follows:

- SCL on Port 0 -> GP21
- SDA on Port 0 -> GP20

The 5V I2C pins are hardwired to the Pico pins as follows:

- SCL on Port 1 -> GP19
- SDA on Port 1 -> GP18

Many peripherals can be daisy-chained onto the I2C busses at once, provided the microcontroller can provide sufficient power and that the I2C bus maintains sufficiently communication signals on the SDA and SCL lines. The 5V linear voltage regulator onboard the *Pico Base + Proto* is rated for 1.0A, meanwhile the 3.3V regulator onboard the Pico is rated for 0.3A (see the Pico datasheet).

If a need arises to add pull-up resistors, for example, on the SDA and SLC lines (either for 3.3V or for 5V bus), the use can use the top four rows-of-four breakout sections near the centre of the board to connect resistors via the adjacent prototyping section. For further details, see Section 3.13.

7 RESOURCES

The following are resources relating to the *Pico Base + Proto*.

- Example Arduino IDE sketches showing various features of the *Pico Base + Proto*. This includes how to use the programmable buttons and LEDs, how to use the I2C Port 0 and Port 1, and others.
  https://github.com/PTSolns/PTSolns_PicoBase

- PTSolns *Pico Base* datasheet.
  "Datasheet_PTSolns_PicoBase_RevX.pdf"

- Raspberry Pi Pico datasheet.
  https://datasheets.raspberrypi.com/pico/pico-datasheet.pdf

- Sparkfun's Qwiic® Connect system.
  https://www.sparkfun.com/qwiic