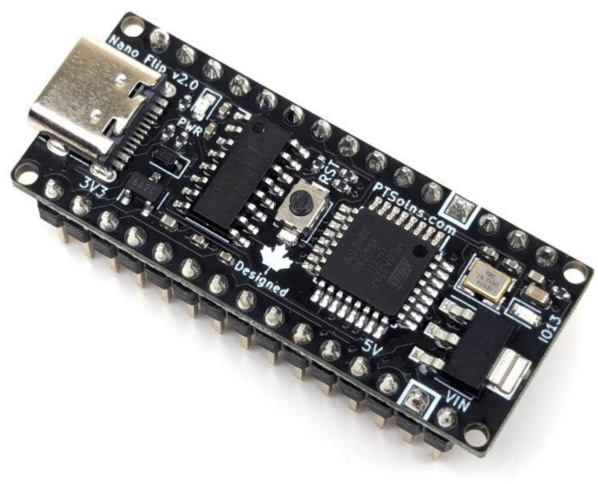
Nano Flip

1 DESCRIPTION



The PTSolns *Nano Flip* is the modern twist on the classic Nano microcontroller. The popular ATmega328P microcontroller is embedded on the *Nano Flip*, providing all the features users come to expect. A large online community, tutorials, and support makes the *Nano Flip* a great choice in educational, hobby and professional settings for any project from getting started in the world of microcontrollers to rapid prototyping, and everything in between.

Users can program, as well as power, the *Nano Flip* via the industry standard USB-C Port. Alternative power options are also available. The small board footprint makes the *Nano Flip* a very useful board for anyone working with a standard-pitched breadboard or prototyping boards. When plugged into a breadboard, the board only takes up five rows, leaving another five rows available. This makes rapid prototyping and breadboard experimentation convenient and efficient.

Onboard the *Nano Flip* is a reset (RST) button, a power (PWR) LED, and a programmable (IO13) LED. The PWR LED can be disconnected by cutting a jumper pad on the back of the board. A secondary jumper pad on the back of the board allows the user to completely disconnect the 5 V power management circuitry from the rest of the onboard components. This gives a lot of flexibility to the user, such as for example the *Nano Flip* can be used as a 5 V power supply.

The *Nano Flip* comes ready-to-use out-of-the-box. Male headers are assembled onto the board and bootloader is burned. Furthermore, a custom sketch is uploaded to the board. This sketch allows the user to immediately start experimenting with the *Nano Flip* without any initial software installations. This “GetStarted” sketch is outlined in detail in Section 6.2.

The *Nano Flip* is compatible with a range of products such as the PTSolns *NTEA-Series*, the PTSolns *Proto-N2RF*, and others.

All *Nano Flip* boards are individually inspected and marked with a quality control sticker (either on the PCB, or on the packaging).

Table of Contents

2 DOCUMENT REVISION HISTORY

Current document revision is Rev 1.

Changes to Rev 1

- Fixed typo regarding breadboard, including updating photo.
- Fixed minor typos on units.
- Fixed heading numbers.
- Fixed typo in GPIO I/O current draw.
- Updated pinout diagram with more labels. Added sub-sections for several pin definitions.

3 PRODUCT FEATURES

This section highlights notable features of the *Nano Flip.*

3.1 USB-C Port

The *Nano Flip* has a USB-C Port onboard, as shown in Figure 1, which can be used to both power the board as well as program it.

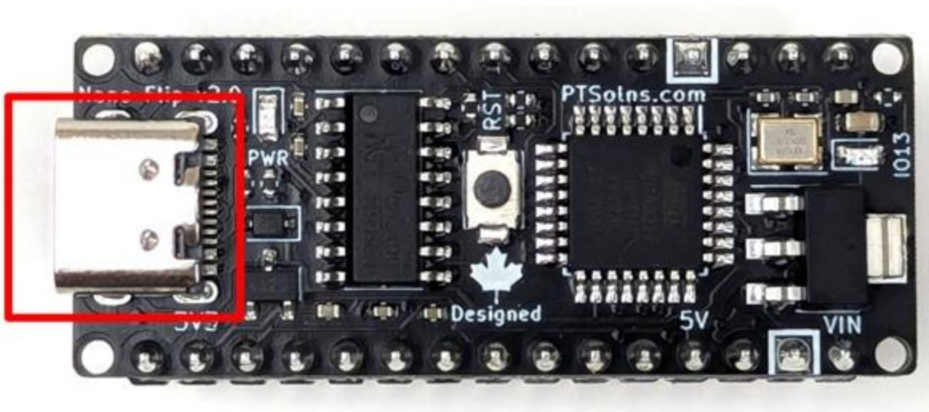


Figure 1: The USB-C Port on the Nano Flip.

3.2 Reset Button

The *Nano Flip* has a reset (RST) button onboard, as shown in Figure 2. Pressing the RST button pulls the RESET pin of the ATmega328P to ground (GND), causing a complete reset of the microcontroller.

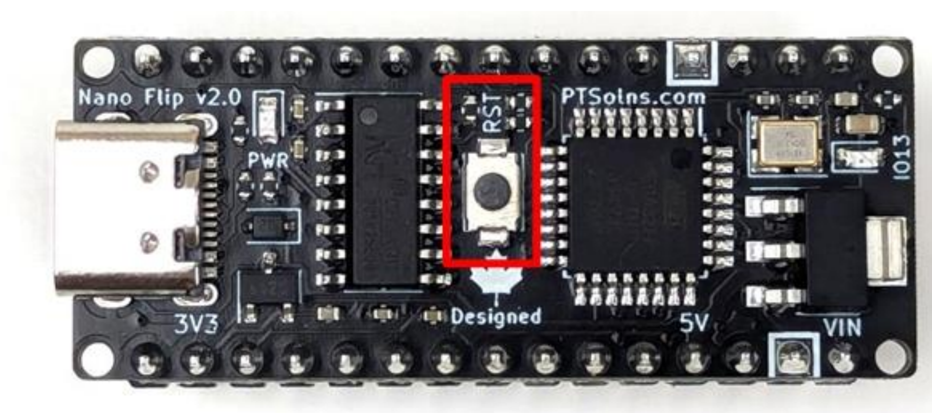


Figure 2: The reset (RST) button on the Nano Flip.

3.3 Power and Programmable LEDs

Onboard the *Nano Flip* are two LEDs. When the board is powered the power (PWR) LED is illuminated. A programmable LED, labelled IO13, connected to digital pin 13 (D13), also exists onboard. Both of these LEDs are shown in Figure 3. Furthermore, the PWR LED can be disabled by cutting the jumper pad (closed by default), which is located on the back of the *Nano Flip*, as shown in Figure 4.

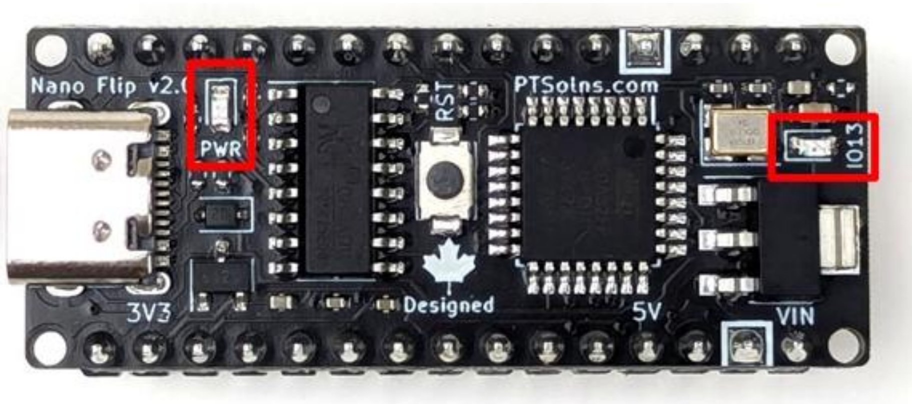


Figure 3: The power (PWR) and programmable (IO13) LEDs on the Nano Flip.

Figure 4: The back of the Nano Flip showing the PWR jumper pad (closed by default).

3.4 Board Footprint

The width of the male headers on the *Nano Flip* are six multiples of the standard pitch of 2.54 mm / 0.1 in. This allows the *Nano Flip* to be placed onto a standard breadboard, with five rows on the breadboard remaining available.

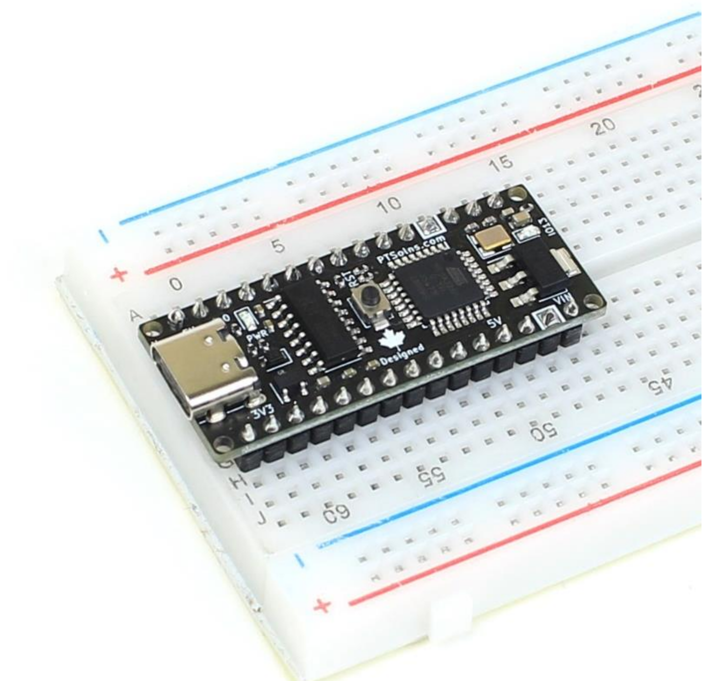


Figure 5: The Nano Flip placed into a standard breadboard.

3.5 Pinout Diagram

The pinout diagram is shown in Figure 6. For more information about the pin definitions, see the following subsections. For electrical ratings see Section 5.

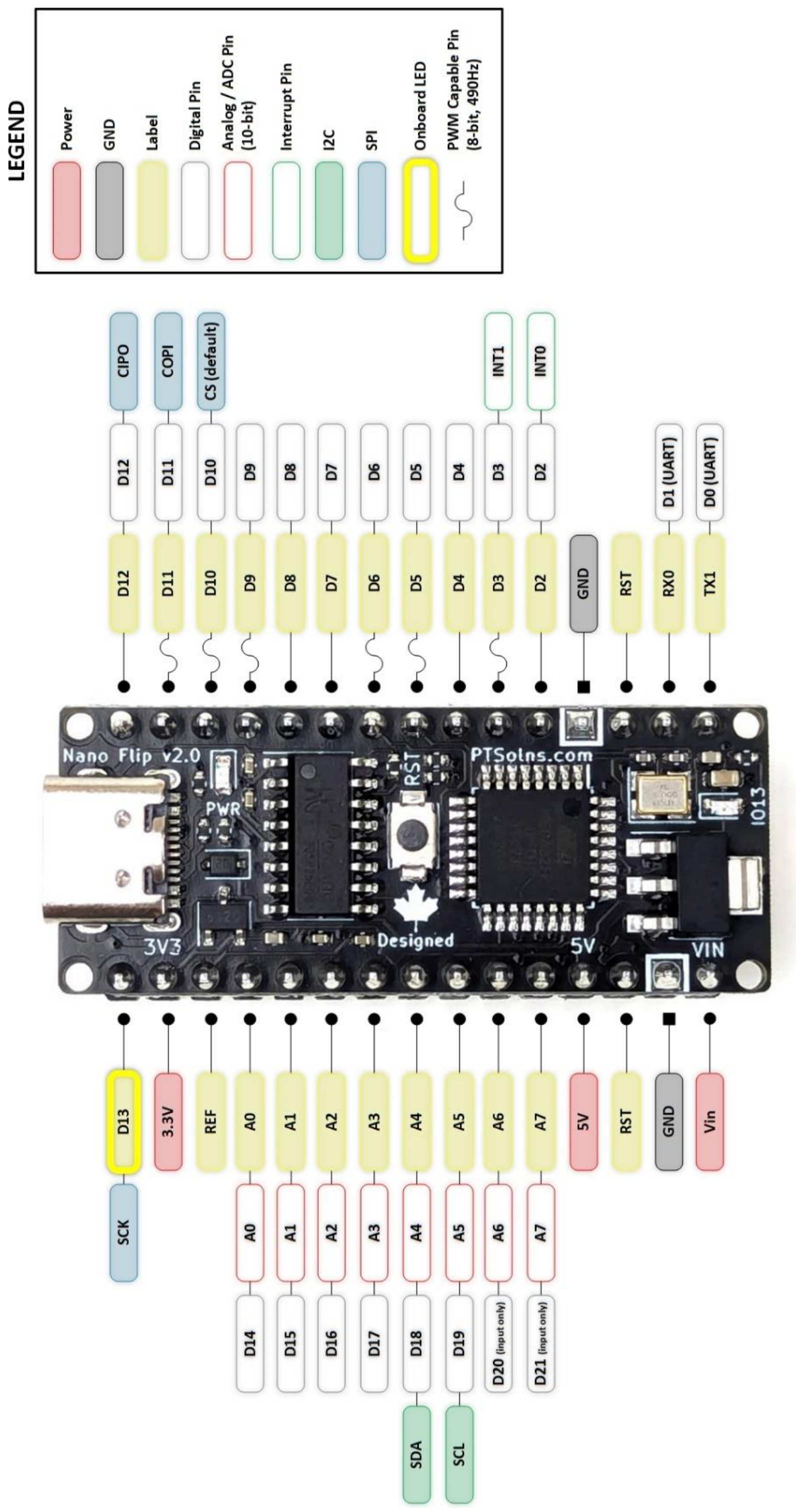


Figure 6: Pinout diagram of the Nano Flip.

3.5.1 Digital Pins

There are 14 digital pins (D0 to D13), with six of these Pulse-width modulation P(WM) capable. The PWM capable pins are:

- D3
- D5
- D6
- D9
- D10
- D11

The PWM capable pins have a resolution of 8-bit, and a default frequency of 490 Hz).

Furthermore, the analog pins (see Section 3.5.2) can also act as digital pins. These additional digital pins are:

- D14 (A0)
- D15 (A1)
- D16 (A2)
- D17 (A3)
- D18 (A4)
- D19 (A5)
- D20 (A6)
- D21 (A7)

NOTE: Digital pins D0 and D1 are the serial communication pins (UART). Using these pins for other purposes is not advised and should be done with caution to avoid unintended consequences (E.g. interference with the Serial Monitor in Arduino IDE).

NOTE: Pins D20 and D21 can only be used as inputs.

3.5.2 Analog / ADC Pins

There are eight analog / ADC pins (A0 to A7). Their resolution is 10-bit.

3.5.3 GPIO Pins

All the digital and analog pins are collectively referred to the General-Purpose Input/Output (GPIO) pins. Although, as discussed in Section 3.5.1, there are some important limitations/considerations on some of the digital pins.

All GPIO pins have internal pull-up resistor, typically between 20 kΩ to 50 kΩ, which are by default disabled. These can be enabled via software.

3.5.4 Interrupt Pins

There are two interrupt pins on the digital pins D2 and D3. Interrupt pins allow the microcontroller to respond immediately to certain events, which can be crucial for real-time applications. These pins have the following trigger modes:

- LOW: Triggered when the pin is low.
- CHANGE: Triggered when the pins changes value (rising or falling).
- RISING: Triggered when the pin goes from low to high.
- FALLING: Triggered when the pin goes from high to low.

3.5.5 I2C Pins

The I2C (Inter-Integrated Circuit) pins are used for communication with I2C devices, which is a popular serial communication protocol for connecting sensors, displays, and other peripherals. The I2C bus is designed for communication between multiple devices using only two wires: one for data and one for the clock. The following pins define the I2C bus on the *Nano Flip*:

- A4: Serial Data Line (SDA)
- A5: Serial Clock Line (SCL)

The default (Standard Mode) data rate is 100 kHz. The I2C bus is capable of increased data rates of up to 300 kHz (Fast Mode).

The I2C pins have internal pull-up resistors (typically 20 kΩ to 50 kΩ), but external pull-up resistors (4.7 kΩ to 10 kΩ) are recommended for reliable communication, especially with longer cables or more devices.

3.5.6 SPI Pins

The Serial Peripheral Interface (SPI) pins are used for high-speed synchronous serial communication between the microcontroller and various peripherals like sensors, displays, and memory chips. The following pins define the SPI bus on the *Nano Flip*:

- D10: Chip Select (CS). Used to select the SPI device for communication.
- D11: Controller Out Peripheral In (COPI). Ends data from the controller to the peripheral device.
- D12: Controller In Peripheral Out (CIPO). Receives data from the peripheral device to the controller.
- D13: Serial Clock (SCK). Provides the clock signal to synchronize data transmission.

The *Nano Flip* can operate at SPI clock speeds up to 8 MHz.

NOTE: The CS pin is set by default to digital pin D10. However, this can be changed in software.

3.6 Silkscreen Printing

All the pins are labeled on the back of the *Nano Flip*, as shown in Figure 4. A pinout diagram can be found in Section 3.5. The power pins are labelled on the front of the board. On the front of the board the two ground (GND) pins are marked with a white square around the pin.

3.7 Isolating 5 V Power Supply

On the back of the *Nano Flip* is a jumper pad, as shown in Figure 7. The 5 V power supply can be completely isolated from the rest of the onboard components when this trace is cut.

Figure 7: The 5 V Isolate jumper pad on the back of the Nano Flip.

3.8 Mark of Authenticity

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 and Figure 9, respectively.

Figure 8: The "PTSolns" trademark found on authentic PTSolns PCBs.

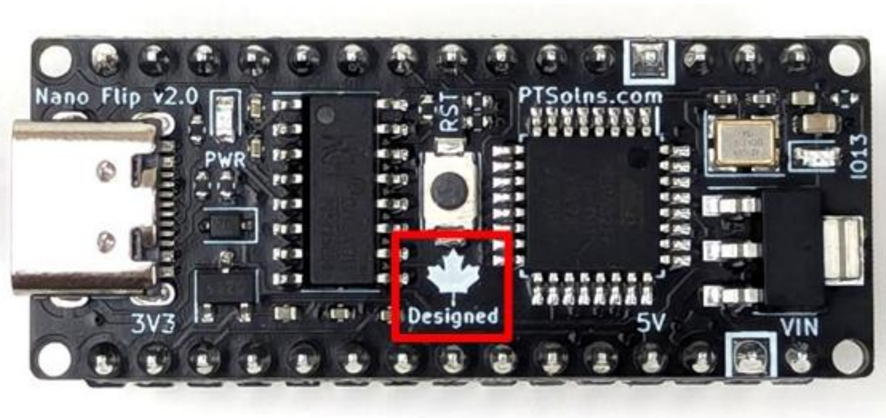


Figure 9: The "Canadian Designed" symbol found on authentic PTSolns PCBs.

4 PHYSICAL PROPERTIES

The physical properties of the *Nano Flip* are outlined in Table 1.

Table 1: Physical Properties.

	Quantity	Value	Reference
PCB	Length	43.18 mm	Figure 10
	Width	17.78 mm	Figure 10
	Thickness	1.6 mm	--
	Weight (with headers)	6 g	--
	Color	Black	--
	Silkscreen	White	--
Material	Lead free HASL-RoHS surface finish		--
	FR-4 base		--
Mounting Holes	4x each with 1.651 mm diameter		Figure 11

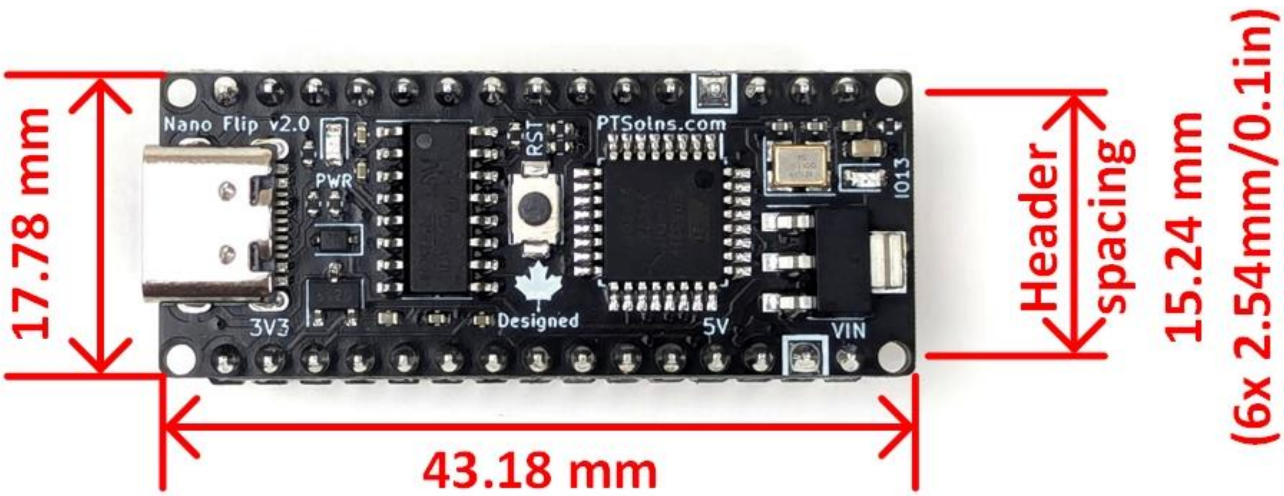


Figure 10: Dimensions of the Nano Flip.

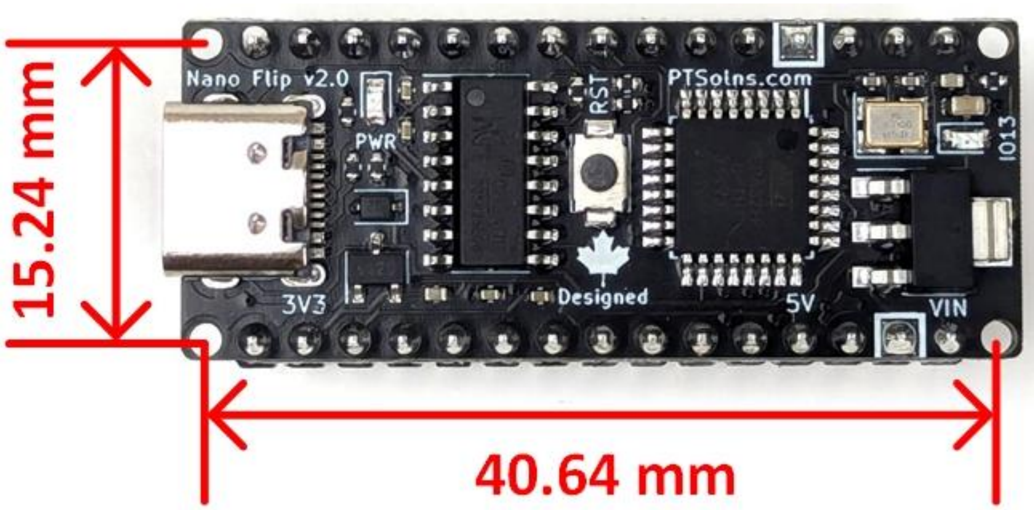


Figure 11: Positions of mounting holes.

5 ELECTRICAL PROPERTIES

The electrical ratings for the *Nano Flip* are outlined in Table 2.

Table 2: Electrical ratings for the *Nano Flip*.

Type	Rating
Input voltage on USB-C	5 V
Input voltage on VIN pin	7-12 V
Operating current draw on any single GPIO	20 mA
Absolute max current draw on any single GPIO	40 mA **(Do not operate at this level for extended periods)**
Max combined current draw on all GPIO	200 mA **(IF OPERATING in "Stable" CONDITIONS. See Section 5.1 for important details)**
Max current draw on 3.3 V power pin	160 mA **(IF OPERATING in "Stable" CONDITIONS. See Section 5.1 for important details)**
Max current draw on 5 V power pin	800 mA **(IF OPERATING in "Stable" CONDITIONS. See Section 5.1 for important details)**
Max combined current draw on all GPIO and power pins (Total External Current Draw (TECD))	800 mA **(IF OPERATING in "Stable" CONDITIONS. See Section 5.1 for important details)**

The current ratings for the two power pins, the 3.3 V and 5 V pins, are discussed in more detail in Section 5.1. The voltage ratings are discussed in Section 5.2.

5.1 Current Rating

The onboard components on the *Nano Flip* consume approximately 20 to 40 mA, depending on the LEDs and the ATmega328P microcontroller demand. External current draws can be made by employing any of the General-Purpose Input/Output (GPIO) pins, such as the digital or analog pins, as well as the 3.3 V and 5 V power pins. The 3.3 V and 5 V power pins can be used to power external sensors and modules. The combined current draw of any GPIO and power pins used is the Total External Current Draw (TECD).

The TECD is delivered by an onboard 5 V voltage regulator. Depending on the input voltage (Vin) supplied to the regulator, as well as the TECD, the *Nano Flip* may operate in the "Stable" region or the "Unstable" region. This is shown in Table 3. In this context, "Stable" is defined such that the 5 V line remains constant, with a small ripple, within acceptable tolerances. "Unstable" is defined such that the 5 V line starts to drop below unacceptable tolerances, collapses, or rises above 5 V plus an acceptable tolerance. The user should only operate the *Nano Flip* in the "Stable" region. In extreme unstable regions (e.g. Vin = 12 V, TECD = 800 mA), the voltage regulator may allow the input voltage through to the 5 V line. This can cause damage to components downstream, and the user must avoid such extreme conditions at all times.

As an example, at an input voltage of Vin = 7 V, the TECD can reach the maximum of 800 mA. With increasing input voltages, the TECD in which the *Nano Flip* operates in the "Stable" regions starts to reduce.

Therefore, the user should take care that all current draws on external pins (GPIO, 3.3 V and 5 V power pins) remains in the "Stable" region for a given input voltage Vin, as outlined in Table 3.

Table 3: TECD Operating Conditions.

Total External Current Draw (TECD)
(Not including current draw of onboard components)

Vin	0.0 A	0.1 A	0.2 A	0.3 A	0.4 A	0.5 A	0.6 A	0.7 A	0.8 A
7.0 V	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
7.5 V	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Unstable	DNO
8.0 V	Stable	Stable	Stable	Stable	Stable	Unstable	DNO	DNO	DNO
8.5 V	Stable	Stable	Stable	Stable	Unstable	DNO	DNO	DNO	DNO
9.0 V	Stable	Stable	Stable	Stable	Unstable	DNO	DNO	DNO	DNO
9.5 V	Stable	Stable	Stable	Unstable	DNO	DNO	DNO	DNO	DNO
10.0 V	Stable	Stable	Stable	Unstable	DNO	DNO	DNO	DNO	DNO
10.5 V	Stable	Stable	Stable	Unstable	DNO	DNO	DNO	DNO	DNO
11.0 V	Stable	Stable	Stable	Unstable	DNO	DNO	DNO	DNO	DNO
11.5 V	Stable	Stable	Unstable	DNO	DNO	DNO	DNO	DNO	DNO
12.0 V	Stable	Stable	Unstable	DNO	DNO	DNO	DNO	DNO	DNO

Stable	Voltage on 5 V line remains stable.
Unstable	Voltage on 5 V line collapses and becomes unstable.
DNO	Do No Operate!

NOTE 1: Drawing full allowed current and temperature of 5 V voltage regulator

If the TECD is high the voltage regulator will get hot. This is unavoidable and depends greatly on the input voltage. The component's temperature depends on how much power (in Watts) it has to dissipate. This power is a result of the voltage difference between the Vin and Vout of the voltage regulator, times the current being draw. This can be expressed in the following formula:

$$Power_{dissipate\ on\ volt.reg} = (V_{in} - V_{out}) * I$$

The input voltage (discussed more in Section 5.2) ranged from 7 V to 12 V. The most power entering in the voltage regulator needing to be dissipated in terms of heat is when Vin = 12 V and the TECD is the maximum of 800 mA. In that case, the power to be dissipated becomes (12 V – 5 V)*800 mA = 5.6 W. This is a lot of power for such a small SMD component. The component will heat up! The 5 V voltage regulator will automatically shut off when the internal component temperature reaches 145 degrees C. The component restarts when the temperature is below a threshold.

The *Nano Flip* was developed with the temperature and current ratings in mind. The traces within the PCB that carry the current have been made very wide to reduce the temperature. This is particularly the case for the trace to the 5 V power pin. Furthermore, thermal vias were added below both the 5 V and 3.3 V voltage regulator. These vias take the surplus heat from under the component and bring it to the other side of the PCB where there is more surface area to dissipate the heat.

5.2 Voltage Rating

The 5 V voltage regulator determines the maximum and minimum acceptable voltage input a user can supply. The maximum is set to 12 V. However, the regulator can accept short momentary voltage spikes up to 14 V caused by the external power source. The user should be careful to never exceed the 12 V rating as otherwise damage to the components can result. If the input voltage is too high the regulator can malfunction, allowing high input voltage on the 5 V line, causing other components downstream on the 5 V line to be damaged, including the ATmega328P. Therefore, if wanting to supply the *Nano Flip* with a 12 V source, particularly from a battery or an unstable buck/boost converter, ensure that the voltage is not above the 12 V rating.

The minimum input voltage is specified as 7 V. With 7 V the *Nano Flip* can reliably be operated. That being said, the voltage can likely be a little bit lower. It depends on how much current is being drawn through the 5 V voltage regulator, as well as the fuse settings on the ATmega328P. The higher the current draw, the larger the dropout voltage is. At 800 mA current draw, the regulator drops ~1.45 V. An input voltage of 6 V might work well for very low external current draws. The user is encouraged to experiment if in their project setup a lower input voltage is acceptable.

6 USAGE AND APPLICATION

This section presents important information regarding the first-time usage of the *Nano Flip.*

6.1 CH340 Driver & Programming

The *Nano Flip* uses the common CH340 IC to enable communication between what is plugged into the USB-C port (e.g. user's laptop) and the microcontroller (ATmega328P). This IC is required when programming the *Nano Flip.* The driver for the CH340 typically must be installed the first time it is needed in any project. Many boards and modules make use of the CH340 so chances are that the driver is already installed. However, if the driver is not yet installed, the user must first install it in order to program the *Nano Flip.* This installation typically only has to be done once.

SparkFun Electronics has written a comprehensive tutorial on this topic, and the user is referred to their excellent documentation on this. Find the link here:

https://learn.sparkfun.com/tutorials/how-to-install-ch340-drivers/all

There are many other tutorials available online that can be found by searching "CH340 driver installation instructions" or similar.

Once the CH340 driver is installed, the *Nano Flip* can be programmed. To program the *Nano Flip* the user is encouraged to install the Arduino IDE software (free), which can be found here:

https://www.arduino.cc/en/software

To upload a new sketch onto the *Nano Flip* using Arduino IDE, the user simply has to select the board type as "Arduino Nano", and set the Processor as "ATmega328P (Old Bootloader)".

There are several ways a microcontroller can be programmed, but the Arduino IDE is one of the easiest ways to get started quickly, with a large active online community and many tutorials and forums.

6.2 Out-of-the-Box Ready Examples

The *Nano Flip* comes pre-installed with a sketch that allows the user to perform several tests without any initial software uploading or programming. These pre-programmed tests can be used to check the working order of the *Nano Flip,* or to get started quickly making some simple examples. These out-of-the-box ready tests include:

1) Onboard (and Pin 13) LED blinking in unique pattern.
2) Reset makes onboard LED (and Pin 13) blink in fast pattern of four for one cycle.
3) I2C scanner searches for connected devices (5 V or 3.3 V I2C bus, or QWIIC connector) every 5 seconds and prints the results to Serial monitor on baud rate 9600.
4) Pin 9 is on a fading in and out cycle that can drive an external LED accordingly.
5) Analog read on Pin A0 and displayed to Serial monitor on baud rate 9600.

Each of these tests is explained in further detail below. If the user wants to restore the pre-installed testing sketch, it can be downloaded from the PTSolns documentation repository sub-domain:

https://docs.PTSolns.com/IDE_sketches/NanoFlip__GetStarted.ino

6.2.1 Test 1: Onboard LED (Pin 13) Blink Unique Pattern

With the *Nano Flip* powered, the programmable onboard LED (marked "IO13") blinks in a regular unique pattern. The LED will illuminate for 100 mS and turn OFF for 200 mS. If the reset is pressed (see Test 2) the pattern changes momentarily before returning to the same pattern.

The programmable onboard LED (marked "IO13") is also connected to Pin 13, available on one of the pins of the male header (marked "D13"). As a further test, the positive terminal of a standard LED can be put onto the male header Pin 13, with the negative terminal of the LED attached to a resistor (in the range of ~200 Ω to 1000 Ω, give or take). The other free end of the resistor can be plugged onto one of the ground (marked "GND") pins in a male header. The LED and resistor can either be soldered together, or a breadboard can be used to make the electrical connection.

6.2.2 Test 2: Onboard LED (Pin 13) Blink Reset Pattern

The reset button triggers a momentarily different pattern consisting of four rapid blinks of the onboard LED (marked "13") of 50 mS ON and 50 mS OFF. This tests that the *Nano Flip* is restarting properly.

Upon reset the *Nano Flip* output several messages to the Serial monitor on baud rate 9600. To see these messages, load the Arduino IDE software and plug in the *Nano Flip* (ensure that the CH340 driver is installed – see Section 6.1). Turn on the Serial monitor (select baud rate 9600) and read the output window.

6.2.3 Test 3: I2C Scanner

Every five seconds the I2C bus (A4/SDA and A5/SCL) is scanned for any connected peripherals. The I2C bus is available on the male header pins (See Section 3.5 for the pinout diagram). The results of the scan are printed to the Serial monitor on baud rate 9600. To see these results, load the Arduino IDE software and plug in the *Nano Flip* (ensure that the CH340 driver is installed – see Section 6.1). Turn on the Serial monitor (select baud rate 9600) and read the output window.

The user can connect several I2C peripherals at once. All the device addresses will be displayed in the Serial monitor.

6.2.4 Test 4: Pin 9 Fade

Pin 9 available on the male header (marked "D9") is a PWM capable pin. PWM allows a pin to be driven at different duty cycles. This, among many other examples, can be used to dim, or fade, an external LED. In a similar fashion as outlined in Test 1, connect an LED plus resistor to Pin 9 and ground (marked "GND") and observe the LED fading pattern. Ensure that the LED positive terminal is in Pin 9 and that the negative terminal goes toward GND through the resistor.

6.2.5 Test 5: Analog A0 Read

The analog pin A0 is programmed to be continuously reading any input connected to it. The read input value is displayed in the Serial monitor on baud rate 9600. To see these results, load the Arduino IDE software and plug in the

Nano Flip (ensure that the CH340 driver is installed – see Section 6.1). Turn on the Serial monitor (select baud rate 9600) and read the output window.

The user can plug a wire directly onto the male header pin A0 and the other end onto:

- A0 to Ground (marked “GND”)
- A0 to 3.3 V
- A0 to 5 V
- A0 free floating

The output as displayed in the Serial monitor will read different values accordingly. A properly working *Nano Flip* should produce the following results:

- A0 to Ground (marked “GND”) -> Output around 0
- A0 to 3.3 V -> Output around 660, plus or minor a few
- A0 to 5 V -> Output around 1023, plus or minor a few
- A0 free floating -> Output ranges widely

7 REFERENCES

This section lists relevant references.

- ATmega328P datasheet by Microchip Technology:
  https://www.microchip.com/en-us/product/atmega328p
- Arduino IDE software (See Section 6.1):
  https://www.arduino.cc/en/software
- PTSolns' Documentation Repository Sub-Domain:
  https://docs.PTSolns.com
- PTSolns website:
  https://PTSolns.com/
- *Nano Flip* default installed testing sketch (See Section 6.2):
  https://docs.PTSolns.com/IDE_sketches/NanoFlip__GetStarted.ino
- CH340 driver installation tutorial by SparkFun Electronic (See Section 6.1):
  https://learn.sparkfun.com/tutorials/how-to-install-ch340-drivers/all