Power

The Ultimate Guide to Powering Your Arduino Uno Board

This is an article from the Tech Explorations Blog

Peter Dalmaris

Understanding the power requirements is crucial for any enthusiast using the Arduino Uno in their projects. How you manage voltage, amperage, and power sources impacts the success or failure of your endeavours.

In this guide, I'm exploring the details of properly powering your Arduino Uno, ensuring you strike that perfect balance for optimal performance.

From the nuances of the onboard voltage regulator to the array of power supply options available, powering an Arduino Uno is more than just plugging in a power source. Learning the voltage limits and recommended ranges is as essential as selecting the correct resistor for your circuit. This article will explain the technicalities behind these little boards that have revolutionized DIY electronics.

In this article, I will document the various methods of powering an Arduino Uno, from USB connections to external power supplies, while ensuring the safety and durability of your board. Whether you're a seasoned tinkerer or a curious newbie, this guide is your handbook for navigating the power pathways that bring your Arduino projects to life.

Please note that this article covers the power options for the genuine Arduino Uno R3. Various clones may have different power options; you can expect at least some minor deviations from what I describe here. I am also considering a similar article for the new Arduino Uno R4 boards.

Understanding Power Requirements

The Arduino Uno R3 is a versatile microcontroller board that can be powered through various methods, making it convenient for different projects and applications. It can accept an input voltage range of 6 to 20 volts. Internally, the board regulates this voltage to meet the proper functional levels of 5 and 3.3 volts for its components and connected peripherals.

Powering the board can be done in two primary ways: using a USB connection or an external power supply. The power source is selected automatically, with a preference for a higher voltage source in cases where more than one is connected simultaneously. While the Uno can handle a wide range of input voltages, the recommended operating voltage for stable performance is between 7 and 12 volts. This recommended voltage, combined with a current rating of approximately 800mA, ensures the most efficient operation of the board without risking overheating or instability.

The Arduino Uno board provides multiple ports for power input—typically a USB port for 5V direct power from a computer or USB charger. This DC power jack fits a 2.1mm center-positive plug for external power supplies such as AC-to-DC adapters, battery packs, and power pins that can accommodate wired power sources like a battery connector. When deciding on what power connector to use, users must evaluate the power source available and the energy requirements of their project to choose the most appropriate power supply method.
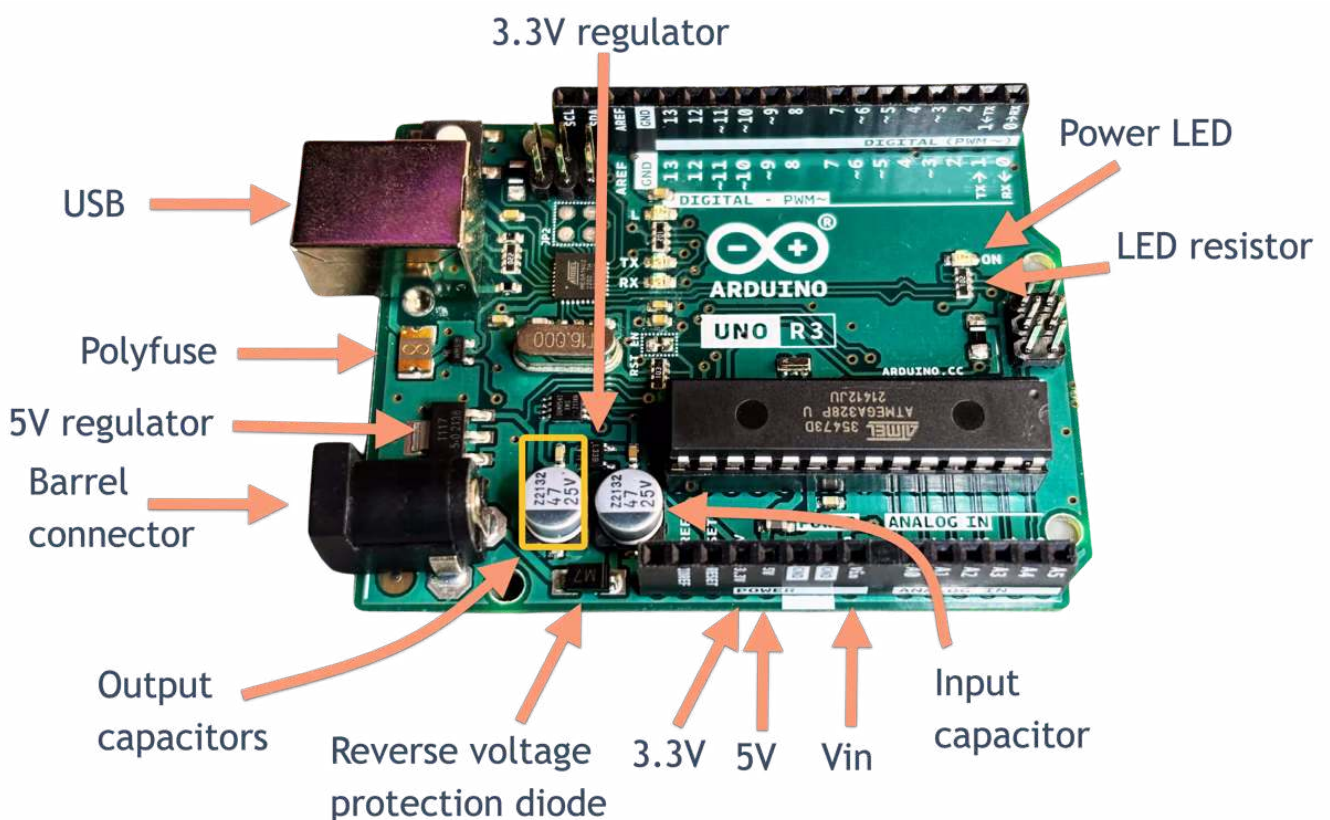
The power-related components on the Arduino Uno R3 board.

Arduino Uno R3 Voltage and Power Basics

The Arduino Uno R3 offers several power options. The one you choose depends on your project characteristics. A 12V AC-DC adapter with a 2.1mm centre-positive plug is sufficient when you're near a wall socket, while a 9V battery can be used for portability when working in remote locations. When using the board's USB port, typically, a USB cable is used to supply 5 volts directly from a computer or USB charger.

Additionally, the onboard Atmega16U2 chip, which acts as a USB-to-serial converter, can be powered through the USB connection or an external power supply. While the board can accept an external power source up to 20 volts, it automatically selects the power source based on the highest voltage available to feed into the onboard voltage regulator.

Input Voltage Limit of the Arduino Uno R3

Your Arduino Uno R3 can tolerate and operate under a minimum and maximum voltage limit. The board has a 5V regulator that requires a minimum of 6.2 volts to operate correctly. This regulator can work with input voltages from 6 to 20 volts. However, providing an input voltage within the recommended range of 7-12 volts through the DC jack is advised to prevent unnecessary power loss as heat, which is more likely to happen at higher voltages.

Resettable Polyfuse and Reverse Polarity Protection

One particular feature of the Arduino Uno is its built-in protection against reverse polarity in the DC power jack input. When a user accidentally connects a center-negative plug, a protection diode shields the board from potential damage, a testament to the robust design of the Uno.

While the DC jack is safeguarded, not every power input point shares this level of protection. It's important to note that the VIN pin on the Arduino boards lacks reverse polarity protection. Careful attention is required when using this pin, as incorrect polarity can immediately damage the board. Similarly, the 3V3 and 5V pins directly connect to the onboard voltage regulators, sharing this absence of reverse polarity protection. Any accidental reversal of input voltage on those pins necessitates extreme caution.

To tackle issues like shorts and overcurrent scenarios, the Uno board includes a resettable polyfuse. This polyfuse works hand in hand with the diode for reverse polarity protection and protects not just the board but also the USB devices, computers, and power supplies connected to it.

The Uno's reliable design is further enhanced using a DFU bootloader programmed into the ATmega16U2/8U2 chip. This enables high programming flexibility and ensures the board is protected during software operations, making it robust and user-friendly.

Recommended Voltage Range for Arduino Uno

One key consideration when powering an Arduino Uno is adhering to the recommended voltage range to ensure optimal performance and safety. While the board can handle a broad spectrum of input voltages, maintaining a source voltage between 7 and 12 volts is the sweet spot. This range is optimal for the onboard voltage regulator, which steps down the input voltage to a consistent 5 volts required by the microcontroller and peripheral components.

You can supply power to the Arduino Uno using an AC-to-DC adapter connected via the board's power jack. This jack is typically fitted with a 2.1mm center-positive plug. Another alternative is using a battery, and in cases such as this, it is best to connect a 9V battery directly to the power pins (Vin and GND). The board's internal voltage regulator will regulate the input voltage from these power sources, supplying a stable current for your projects.

Power Supply Options for Arduino Uno

The flexibility of the Arduino Uno's power supply options is one of its many advantages. The board can be powered directly via the USB connection from a computer or USB charger. Alternatively, an external power supply can be used —whether it's through an AC-to-DC adapter, commonly referred to as a "wall-wart," or a portable battery pack. The inclusion of intelligent switching circuitry ensures the board can automatically select the highest voltage source available between the USB and external power options.

Let's look at these options next.

Onboard Voltage Regulator and Power Pins

The Arduino Uno board has an onboard voltage regulator and strategically placed power pins for powering the board and external devices. The VIN pin, for instance, operates as a dual-fledged power pin. It can draw voltage from an input to the regulator and also serves as a power output when the board is powered through the barrel jack connector. Regulated voltages of 5V and 3.3V from Uno's voltage regulator are available directly on the 5V and 3.3V pins to power sensors and other low-power devices.

You should be careful when using the VIN pin for unregulated power input, as this pin bypasses the onboard reverse polarity protection. To avoid overvoltage damage, it's essential to ensure that the power supplied is within the specific voltage ranges designated for the Uno. These design features help users integrate the board into various projects while managing power needs effectively.

Powering Arduino Uno with USB

Powering the Arduino Uno with a USB connection utilizes the USB port of the board to receive up to 500mA of current at 5V from a host computer, laptop, or USB charger. This power delivery is dependable for most small-scale projects and initial prototyping.

The board's design includes intelligent power source selection. If the Arduino Uno is connected to a USB and an external power supply, it automatically chooses the higher-voltage source, ensuring the most efficient operation.

The USB port on the Arduino Uno board is a standard Type B connector. When connected to a computer, it supplies 5V and can provide either 500mA if the device is properly enumerated or 100mA if not. Enumeration is when the host computer recognizes and configures the connected device, enabling the drivers necessary for communication over USB and determining the device's capabilities and power requirements.

Different Arduino models feature various USB connector types, such as the Mini B connector found on the Nano. Regardless of the type, these USB connectors typically supply 5V and a current of up to 500mA due to USB specifications. USB-powered sources like power banks and adapters can also provide a regulated 5V line at various current capacities, making them suitable for supplying power to Arduino boards without a computer.

When using a USB cable to power the Uno, it's essential to understand that current delivery will vary depending on whether the USB connection is enumerated. 500mA is available when enumerated, and 100mA is available when the connection is not initiated correctly. Enumeration becomes crucial as it allows Arduino Uno to pull sufficient power for most applications that don't require additional external components to draw high currents.

Using a USB cable for power eliminates the need for an external power source, greatly simplifying the setup. This method is ideal when working with low-power sketches or debugging. Its simplicity makes it a go-to for hobbyists and professionals alike when on the go or at a workstation.

External Power Supply Options

The Arduino Uno can be powered using an external power supply, one of the most reliable methods for operating your electronics projects. This approach is particularly useful when your project consumes more current than the USB connection can provide or when you need to install your project in a location without access to a computer.

External power can come from two primary sources: an AC-to-DC adapter, often called a "wall wart," or a battery. The adapter should ideally provide a voltage output between 7 and 12 volts, which is the sweet spot for the onboard 5V regulators to operate efficiently without generating excessive heat. Users can connect the adapter to the Arduino Uno's power jack using a 2.1mm center-positive plug.

Battery power can also be utilized, with various types available, such as 9V batteries, AA or AAA battery packs, or even lithium polymer (LiPo) batteries. Users can hook up a battery to the Arduino Uno board using the GND and Vin pin headers of the POWER connector. Like with the AC-to-DC adapter, the voltage supplied should be within the 6 to 20 V range to maintain proper functionality.

Barrel Connector and Barrel Jack

The barrel jack, also known as a barrel connector, is the most recommended method for powering the Arduino Uno once your project is ready for deployment. This connector accepts a standard 2.1mm center-positive plug from an adapter that provides 7 to 12 volts. The voltage supplied through this connector passes through the onboard voltage regulator, ensuring that your Arduino Uno operates safely with a consistent 5V supply.

The barrel connector's configuration is straightforward: the centre pin is positive, aligning with the centre-positive specification of the Uno's power jack, while the outer sleeve is the ground connection. This design helps prevent accidental reverse polarity, which could potentially damage the board.

For battery-operated projects, users can attach a barrel jack adapter to the leads of their battery pack. When using a wall adapter or a battery, the barrel jack provides both a secure mechanical connection and a reliable electrical one. This minimizes the risk of power disruption with the loosening of jumper wires or clips, making the barrel connector the clear choice for most applications.

5V Regulators and Regulated Power Supply

The voltage regulator on the Arduino Uno board is an essential component that allows the use of a range of input voltages while providing a stable 5V output to the board's components. The regulator requires a minimum input of 6.2 volts to function correctly and can handle up to 20 volts. However, staying within the 7-12 volt range is advisable to prevent the regulator from overheating and ensure efficient operation.

Directly connecting power to the 5V pin should be done cautiously, as this method bypasses the onboard voltage regulator. Any power supply unit used in this manner must be a regulated 5V to prevent damage to the Arduino Uno and attached components since there's no protection against voltage spikes or variations.

Ensuring a stable and regulated power supply is paramount, regardless of whether power is connected via the 5V pin, the DC jack, or the USB port. Devices such as computers, USB hubs, power banks, and USB chargers can all supply a steady 5V, but if you're using an alternative power source like batteries, a step-down converter or regulator module may be necessary to achieve the correct voltage.

Battery Power Options for Arduino Uno

The Arduino Uno board's flexibility extends to its power options. It can be powered by various battery configurations for projects requiring mobility or remote placement. A common and straightforward way to provide battery power is by using a 9V battery with a barrel jack connector, offering an easy-to-use solution for field deployments or testing projects away from a computer or other USB power source.

The cost-effectiveness of 9V batteries makes them an attractive option for powering Arduino Uno boards, given their ready availability and straightforward connection process. When opting for battery power, it is essential to consider the Arduino Uno's built-in protective features, such as the resettable polyfuse, which safeguards against excessive current draw that could potentially harm the board or the power source.

Battery power allows for an operating voltage range of 6 to 20 volts, utilizing the Uno's onboard regulator to ensure the supply is diminished to the necessary 5V for the board's operation. This means that users can choose from various battery types and configurations if they conform to the voltage guidelines provided.

9V Battery and 9V Battery Connector

A 9V battery is an excellent option for portable applications or working in areas without electrical wiring. Using a simple snap-in barrel jack connector, the 9V battery connects seamlessly to the board, with the onboard regulator ensuring correct voltage delivery.

AAA Batteries and Battery Pack

For a more compact setup, the Uno can be powered by a 4x AA/AAA 1.5V battery pack, which typically yields around 6 volts. These packs are particularly useful in portable projects when longer battery life is essential. The voltage from these batteries is suitable for the Uno, falling within the 6-20 volt operational range. Remember that as battery power diminishes, voltage regulation can become more critical.

Lithium-ion Polymer Batteries

Lithium-ion polymer (LiPo) batteries are viable for those requiring high energy density and rechargeability. Typically outputting 3.7 volts, they're perfect for MKR series boards with a built-in Li-Po connector and charging circuitry. Given their sensitivity, ensure proper battery connector compatibility and handle these batteries carefully.

Arduino Power Shield

Lastly, an Arduino Power Shield (there are several options, and I have linked to just one of many) can simplify power management when multiple sources are involved. The shield enables a seamless transition between USB, battery, or external adapter sources by automatically selecting the highest voltage available. Integrating a resettable polyfuse adds an extra layer of security, protecting against potential overcurrent situations.

Frequently Asked Questions

How can I power my Arduino Uno board?

The Arduino Uno can be powered via the USB connection, a DC power jack (7-12V), or the VIN pin (7-12V).

Can I power the Arduino Uno using batteries?

You can power the Arduino Uno using batteries by connecting them to the DC power jack or the VIN pin. Make sure to use the appropriate voltage and consider the battery capacity.

What is the maximum voltage I can supply to the Arduino Uno?

The maximum allowed voltage for the Arduino Uno is 20V. However, for optimum performance, staying within the 7-12V range is recommended.

Can I power the Arduino Uno from a power bank?

You can power the Arduino Uno by connecting it to the USB port using a power bank. Make sure the power bank can meet the current requirements.

Is it safe to power the Arduino Uno through the VIN pin with a high voltage?

While the Arduino Uno can accept higher voltages through the VIN pin, it is essential to be cautious and ensure the voltage is within the recommended range (7-12V) to prevent damage to the board.

Is it possible to simultaneously power the Arduino Uno using USB and external power?

You can power the Arduino Uno using USB and external power simultaneously. The Uno will automatically select the power source with a higher voltage.

Can I power the Arduino Uno using the 5V pin?

Powering the Arduino Uno using the 5V pin is not recommended. This pin is meant for output, not for powering the board.

How much current does the Arduino Uno consume?

The Arduino Uno typically consumes around 50-100mA of current when idle. However, the current requirement may vary depending on the connected peripherals and the executed code.

What do I do if the Arduino Uno keeps resetting during operation?

Check your power source and make sure it is providing stable voltage. Also, ensure that your power supply can deliver enough current to meet the requirements of the Arduino Uno and any connected peripherals.

Can I power the Arduino Uno using solar panels?

You can power the Arduino Uno using solar panels by connecting them to the DC power jack or VIN pin. However, to regulate the voltage and current efficiently, you may need additional components, such as a charge controller.

Did I forget something? Did you find errors or omissions?

Your feedback is important to me.

If you have suggestions for improvements, notice any errors, or think something was omitted, please share your thoughts using the comments tool below.

Your input helps me enhance the quality of this content and better serve the community.

Thank you for contributing to the discussion.

I last updated this article on April 22, 2024.