TECHNOLOGY IN ACTION™

Practical Tinker Board

Getting Started and Building Projects with the ASUS Single-Board Computer

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Liz Clark
Boston, MA, USA

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Printed on acid-free paper

*This book is dedicated to my mom, Linda,
for always believing in me and for being an amazing
teacher, both inside and outside the classroom.*

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About the Author

Liz Clark has been creating and working with technology her entire life. Always wanting to learn more, she began a YouTube channel after college called Blitz City DIY to document and share her projects with the hopes of inspiring others to explore electronics, open source and all things DIY. When she isn't coding or soldering a circuit, she can usually be found either playing guitar or hanging out with her two cats, who often make cameos in her work.

Introduction

The goal of Practical Tinker Board is just what the title implies: to provide a realistic guide showing how to best approach and use the Tinker Board single-board computer.

The approach that I took when writing this book was to ask myself what I wish I had known when I was getting started with the Tinker Board, from features to limitations in both software and hardware. As a result, this book contains introductions to many concepts that aren't exclusive to the Tinker Board, because exploring a single-board computer is not a singly focused pursuit; it pulls from many concepts in the realms of open source development and electronics.

After reading this book and following along with the tutorials and projects, you'll have the skills and tools to go forward and create your own projects with the platform. It isn't meant to be an all-encompassing encyclopedia, just to guide you to a point of independence using the Tinker Board. This book also attempts to ease some of the frustrations that often come with using a brand-new piece of hardware. I hope that it helps beginners by making those first steps more accessible and that it provides inspiration for more experienced users. Platforms like the Tinker Board hold so many possibilities that are only limited by the user's imagination and skills. May this book be a resource to help you achieve your goals.

PART I

Getting Started

CHAPTER 1

What is the ASUS Tinker Board?

Before diving in, let's discuss some basics. What is a single-board computer? What can it do? And why would you want to use one in a project?

A Little Context

The maker movement has empowered the everyday person to tap into an intrinsic human element: making things. The ability to create robots or weather stations or other large-scale intelligent devices was once reserved for the most educated among us, with access to expensive equipment and fabrication tools. Now most of these items and skill sets can be acquired by anyone with a modest budget who just has the urge to learn. But as the abilities and interests of makers grow, the power and versatility of the resources must grow as well.

The Tinker Board is a part of the next wave of more powerful maker tools. As a single-board computer, it offers a multitude of options for a maker. It can control hardware with code, it can run specialized operating systems for niche projects, or it can be a small–form-factor computer for personal use.

L. Clark, *Practical Tinker Board*, https://doi.org/10.1007/978-1-4842-3826-4_1

What Is a Single-Board Computer?

But let's back up for a moment. What exactly is a single-board computer? A single-board computer (SBC) has a fairly self-explanatory name. It's a computer that has all of its components fit onto one circuit board that usually fits in the palm of your hand. Most desktop computers have a motherboard with modules that plug in, including the CPU, RAM, graphics card, and so on. By contrast, an SBC usually has everything soldered directly to the board so that the user just needs to provide power and peripherals to be up and running.

System on a Chip

A hallmark of SBCs is that they usually feature a system on a chip (SoC). An SoC is an integrated circuit (IC) that contains most of the main components of a computer in one package that takes up a single spot on a circuit board. The processor is often an Advanced RISC Machine (ARM)-based architecture, which is also found in modern Android phones and Chromebooks.

The power and technology found inside modern consumer devices in an unlocked form factor available to makers has a lot of possibilities. Makers can expand on their project's limits without breaking the bank, which leads us back to the Tinker Board.

The Tinker Board's Hardware

The Tinker Board, illustrated in Figure 1-1, is a lot like other SBCs and does have its own SoC; specifically, a Rockchip RK3288. The RK3288's processor is an ARM Cortex-A17, which has four cores clocked at 1.8GHz. Of course, more experienced users can try overclocking the chip at their own risk.

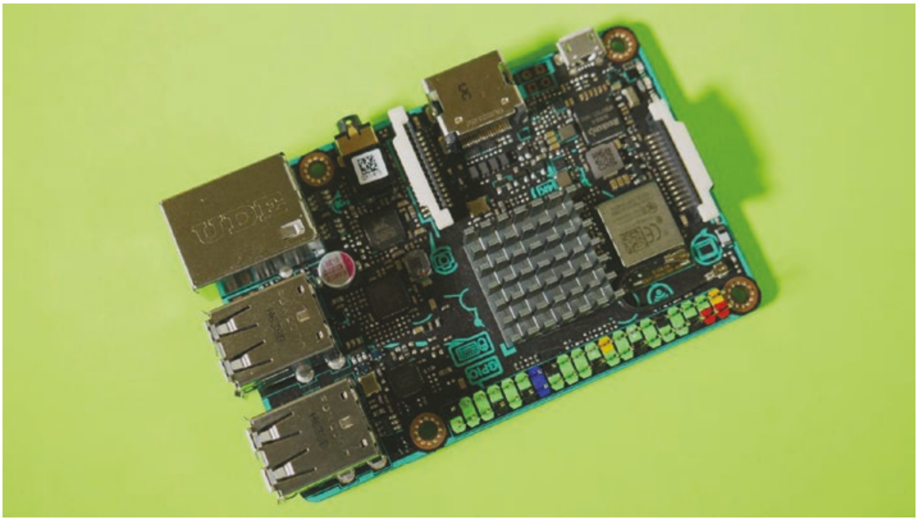

Figure 1-1. *The ASUS Tinker Board*

Its GPU is an ARM Mali-T760, which also has four cores and is clocked at 600MHz. For RAM, it has 2GB of LPDDR3 memory, which gives a nice amount of headroom to avoid bottlenecking with the processor and GPU specs.

For inputs and outputs (I/O), as shown in Figure 1-2, it features four USB 2.0 ports to connect peripherals and HID devices. There is also an Ethernet jack for a wired Internet connection. However, the board also has Wi-Fi capabilities if you need it to be mobile. It takes power through a micro-USB connection but requires a relatively large power supply of at least 5V/2A-2.5A for the original Tinker Board and 5V/3A for the Tinker Board S, which is a consequence of the hefty RK3288.

HDMI 1.4 is available on the board for video at 1080p and 4K for some applications. It can also carry audio, but if you prefer a dedicated audio output there is a 3.5mm headphone jack that can play up to 24-bit/192KHz resolution.

For storage, like other SBCs, the Tinker Board offers a microSD card slot to run the OS and native files. Of course, if you find you need expanded storage you can take advantage of the previously mentioned USB 2.0 ports.

Figure 1-2. *The Tinker Board's four USB 2.0 ports and Ethernet port*

GPIO

One of the Tinker Board's most prominent and unique features, though, is the set of general purpose input/output (GPIO) pins. The GPIO pins are breakout pins that allow external electronic components and circuits to interact with the Tinker Board.

This enables the Tinker Board to go beyond just a small circuit board with the same features as your average PC. By having access to the GPIO, you can build circuits using a variety of components to create unique projects that you have full control over.

There are 40 individual pins arranged in two horizontal rows of 20 (Figure 1-3). Each pin is identified by a number, and the Tinker Board has the GPIO header color-coded so that you can easily tell at a glance what a pin's dedicated function is.

A plus for the Tinker Board is that it shares a GPIO pinout with the Raspberry Pi series of SBCs. This means that existing circuits for the Raspberry Pi can, in most cases, be ported to the Tinker Board with no problems.

There are also add-on modules for the Raspberry Pi series of boards, called HATs and Bonnets. These add-ons have a female port that fits directly onto the GPIO pins and have pre-built circuits for more complicated applications, such as servo motor control, LED matrixes, camera control, and so on. Since the Tinker Board has an identical pinout, these add-ons can in many cases work with the Tinker Board in many cases.

You can use a variety of coding languages to interact with hardware connected via the GPIO pins. Python and C are very popular choices and have many open source libraries available. In a later chapter, we'll go in-depth on the process of developing hardware control applications and build some basic circuits to test features. Most of the projects featured in this book will also take advantage of the GPIO pins.

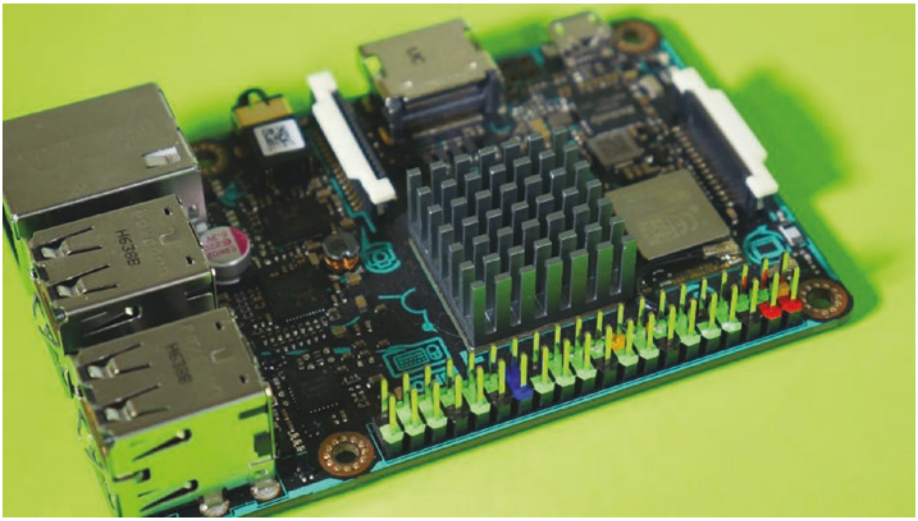

Figure 1-3. *A closer look at the Tinker Board's GPIO pins. Note that they are color-coded to easily identify their individual functions.*

Tinker Board S

The newest update to the Tinker Board family is the Tinker Board S. On the surface, the Tinker Board S looks very much the same as the original Tinker Board. However, there are some key differences that could make a big difference in performance for some projects and use cases.

eMMC

The most notable addition to the Tinker Board S is the inclusion of 16GB of on-board eMMC (embedded MultiMediaCard) flash storage. The advantage of eMMC is that since it's soldered directly to the board, it doesn't utilize a lot of RAM; it can communicate small pieces of data between the other onboard components more easily than external storage.

The speeds are similar to what you'll experience with an SD card, which is why you'll see the biggest advantage with small pieces of data. But when you are working on a project that is pushing the hardware to its limit, on-board eMMC can make a big difference for running your operating system. We'll discuss the different storage methods and what you'll need in the next chapter.

I2S

Looking toward the GPIO, the designers made a significant change to the I2S (inter-IC sound) functionality on the Tinker Board S. As the name suggests, I2S allows sound in the form of PCM audio data to be transmitted between integrated circuits by separating the clock and serial data into separate channels. This is ideal for high-stakes audio applications when dealing with digital systems and is used with DACs (digital-to-analog converters) for high-quality audiophile listening experiences.

Traditionally, the clock speed for I2S can act in either master mode, where the pin's output sets the clock, or slave mode, where the pin accepts the clock from an external source. The original Tinker Board's I2S pins only allowed it to act in master mode, but for the Tinker Board S, the pins can act in either master or slave mode. This gives greater flexibility for audio projects with the Tinker Board S and will allow it to have more compatibility with specialty DACs and ADCs. There are DAC and ADC hats available that fit over the GPIO pins. We'll be looking at these along with a specialized audio operating system in a project later in this book.

An additional audio upgrade on the Tinker Board S is the ability for the board to automatically switch between the 3.5mm jack and HDMI for audio output once a source is plugged in. This will be incredibly helpful for a traditional desktop setup or a home media center project.

Power-on Header

The final update for the Tinker Board S is the addition of a two-pin power-on header. This may seem trivial, but one of the biggest features missing from many single-board computers is the ability to turn the board on discretely. The original Tinker Board, along with many others, can only be turned on by plugging the power supply into the board.

Makers have shared mods that use the GPIO to hook-up a power button, but that sacrifices valuable GPIO pins for a very simple function. Having dedicated pins that are separate from the GPIO on the Tinker Board S for this purpose is very useful and simple for users who want the ability to embed their board in a housing or avoid having to repeatedly unplug and plug in their board.

Original Tinker Board or Tinker Board S?

Aside from these changes, the Tinker Board S is very much the same as the original Tinker Board. It uses the same SoC, GPU, RAM, I/O, GPIO (apart from the updated I2S feature) and form factor. Most users may not even notice the differences between these two boards since the updates to the Tinker Board S are specialized in nature.

However, these updates can also be the difference between a smooth project experience and a frustrating one. When choosing between the two, it's important to consider your use case scenario and make your decision from there. Both boards will be referenced throughout this book to demonstrate if one has an advantage over the other for certain tasks. This should help you in your decision when planning your projects.

Conclusion

It's these features and abilities that bring projects to the next level with the Tinker Board and similar SBCs. Compared to a more basic platform, like the Arduino Uno board, the possibilities expand when it comes to the different peripherals and technologies that you can seamlessly incorporate. For example, providing an Arduino-based project with Internet connectivity is possible, but getting the board online is almost a project by itself. With the Tinker Board, Wi-Fi is already a built-in feature for the board so it's as simple as signing into your network or plugging in an Ethernet cable.

The one thing that could hold the Tinker Board back is the fact that the RK3288 is running on the ARMv7-A architecture, which is 32-bit rather than the more modern 64-bit. However, most SBC operating systems and processes do not utilize 64-bit at this time, so you shouldn't experience issues with your projects. It's just something to keep in mind about the architecture of the hardware.

The RK3288 is built to streamline heavier processes since it has hardware acceleration for larger video files and codecs, which is often a performance choke point for SBCs. It's also been used in many Android phones and Chromebooks; this shows that it can stand-up to everyday use, which is a good vote of confidence for its use in an SBC.

This brings us to a question that you may have asked yourself already: why use the Tinker Board over another SBC where there are so many to choose from? Since the Tinker Board has higher specs than the average SBC, it's perfect for more advanced projects that would have pushed the limits of other SBCs in the past. It's also a great choice for makers or tech enthusiasts who want to dig a bit deeper into different Linux distributions.

So if you're curious about exploring Linux further and building projects that push the boundaries, then the Tinker Board is a good choice for you. In Chapter 2 let's discuss what peripherals you need to take full advantage of the Tinker Board's features.

CHAPTER 2

Ready to Begin: What Do You Need to Use a Tinker Board?

We're almost ready to dive into using the Tinker Board. But before we do that, we need to go over a few very important accessories that will allow you to have a successful experience.

What Do You Need?

As mentioned in the previous chapter, single-board computers arrive with all components installed, so no additional computer hardware modules are needed, besides storage. However, other vital accessories are needed in order to use the Tinker Board properly.

Cooling

The first, and one of the most important, is included in the box. It's the heat sink for the SoC processor. For the processor to operate properly, a heat sink needs to be installed. The heat sink included with the Tinker Board is a good size and will offer proper cooling for everyday use. This method of cooling is called passive cooling, since heat is being expelled without an active force directly applied, such as air or water.

L. Clark, *Practical Tinker Board*, https://doi.org/10.1007/978-1-4842-3826-4_2

You may have used other single-board computers in the past without a heat sink. For lower-powered boards, that is usually fine. However, as mentioned in the first chapter, the Tinker Board is more powerful than many other single-board computers; it has an SoC that is found in consumer products such as Android phones and Chromebooks. With an SoC of this power, a heat sink is not optional. Without it, you may experience thermal throttling, which occurs when a processor cannot perform to its full potential because of overheating. If it operates in this state for too long, it may even damage the SoC and make the board inoperable. It's the electronics equivalent of not giving a plant any water. So please, cool your board responsibly.

Installing the heat sink is simple. On the back is a thermal pad with a sheet of protective plastic. Simply peel off the plastic and stick the thermal pad to the processor. Apply some pressure to ensure good contact between the thermal pad and the processor. After this, the heat sink should be firmly attached to the Tinker Board as shown in Figure 2-1.

If for any reason you ever need to remove the heat sink, replacement thermal pads can be purchased in sheets and then cut to fit the processor die size. You may find over time with heavy usage that this will need to be done to maintain proper temperatures, similar to changing thermal paste on a desktop computer's CPU.

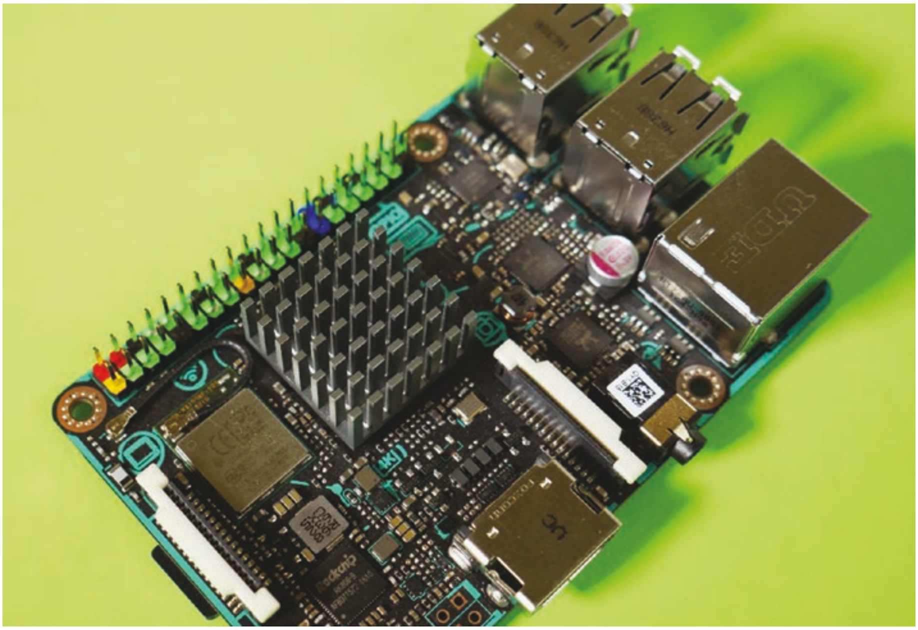

Figure 2-1. *An overhead view of the installed heat sink that is included with the Tinker Board*

Other Cooling Methods

Of course, you aren't limited to this stock heat sink. You can also investigate other, aftermarket heat sinks, if they fit the die size of the processor. This could be helpful in various ways. For example, you could install a shorter heat sink to fit into a housing for a project or a larger heat sink if you know that your project will need better cooling than the stock heat sink can provide. Aesthetics can also motivate a heat sink swap if this will be a visible component in your project and you're going for a certain look.

Heat sinks can also be applied to other ICs on the board, such as the GPU or even RAM if you want to ensure optimal cooling and performance for high-demand projects. The process for applying a heat sink to these ICs would be the same as applying one to the processor. You would just need a thermal pad and heat sink that fit the die size.

Your cooling options aren't limited to just heat sinks, though. You can also attach a small fan, either with a mounting kit or in a case, to a heat sink so that the processor can be actively cooled rather than just passively. This creates a cooling solution similar to desktop PCs that often have a fan and heat sink mounted together over the CPU.

This solution is especially effective when the Tinker Board is in an enclosed housing with minimal natural airflow. You may also want to further emulate a desktop PC's cooling by having enclosure fans bringing air in and expelling it out through vents. By including fans inside the case, you could also keep the board passively cooled without a dedicated fan attached to the processor's heat sink.

A more intensive method would be to cool the board with water cooling techniques. This approach is definitely for enthusiasts, and it's uncertain whether a board of this size and power would really benefit from such an extreme cooling solution, but for an enthusiast who wants optimal temperatures it could be an interesting project.

For this technique, you would need a water block that fits onto the processor's die, as an aftermarket heat sink must, and then a pump and tubing to carry the water. Distilled water is often chosen for water cooling, but specialty fluids are also sold. There are examples of makers implementing this with single-board computers, but again it's unclear that the effort and cost associated with water cooling are viable for a piece of hardware like the Tinker Board. There is also the additional risk of a leak with water cooling, but it would be up to you whether the risk was worth it for the possible reward of optimal temperatures combined with the aesthetic and accomplishment of water cooling.

Note Using a cooling solution outside the heat sink provided by ASUS for the Tinker Board could result in undesired effects or performance. It's important to do your research for your specific cooling need before installing an aftermarket solution.

Power

Once your cooling solution is installed, you're getting closer to using the Tinker Board. But you can't really use the Tinker Board without it being turned on, can you? For this, of course, you'll need a power supply. Power can be delivered to the Tinker Board in two ways. The first, which is the most common and easiest, is through the micro-USB power port with a micro-USB power supply. It's important to make sure that your power supply is rated at 5V/2A-2.5A for the original Tinker Board and 5V/3A for the Tinker Board S. ASUS recommends a linear power supply, but people have had success with switching power supplies as well.

It's important to use a properly rated power supply to ensure that the Tinker Board operates as expected. It has a higher amperage requirement than many other single-board computers because of the power requirements for the RK3288. If you use a power supply that is rated lower than 2–2.5A, you may experience display issues, processing slowdowns, or issues with peripherals plugged into the USB ports. The Tinker Board S will not even boot with a power supply that has an amperage lower than 3A. On the other end of things, if you use a power supply with a voltage rating that is higher than 5V, you may short out the board, since it will be receiving a higher voltage than the components and circuitry are designed for.

Note On the subject of power, if you're in a dry environment that can cause static discharge, please avoid touching the circuitry or ICs on the board without being grounded, as you can inadvertently short out a component and render it inoperable.

Advanced Power Option

For more advanced enthusiast users there is an additional option to power the Tinker Board—use the GPIO pins, which will bypass the on-board regulators. If this is done improperly, though, it can short out your board. However, this power method can be beneficial in certain situations and projects, since it provides a more direct power source that is unfiltered and as a result can allow the board to draw a more stable and slightly higher current. But the benefit to this method is also its detriment, since there is no over-voltage-protection like that found with the micro-USB power option. You are connecting power directly to the 5V line. But if you're feeling brave, you have the electrical experience, and you think you have a genuine use case for it, then you can proceed with caution.

Wiring

First, you'll need a steady and stable 5V power supply line with no more than 1A. This should come from a bench power supply or another trusted source. You'll be connecting the positive lead to pin 2 (5V) and then ground to pin 6 (GND) on the GPIO. Each 5V pin can only handle 1A since there is no filtering on these supply lines. If you need more than 1A available (which you probably will), then you'll need to connect to two 5V pins (pin 2 and pin 4) to have a combined amperage of 2A and two ground pins (pin 6 and pin 9). You can get away with using a single ground pin if necessary, but grounding both connections individually can add more stability to your connection.

Note The Tinker Board's GPIO is color-coded to help in easily visually identifying the pins. The 5V pins are red and the ground pins are black, so this will help avoid any mistakes. We'll be going over the GPIO in more detail in a later chapter.
