Core64 Assembly Guide

INSTRUCTIONS TO ASSEMBLE CORE64 AND CORE64C

Core64 is Designed and Developed by Andrew Geppert
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1. TABLE OF CONTENTS

The latest version of this and related Core64 guides are located at:
https://github.com/ageppert/Core64/tree/master/Documentation

2. VERSION HISTORY OF THIS GUIDE

Revision	Description	Author	Date
A	First draft copied from Gitbook online version.	Andy Geppert	2022-12-23

3. Important Cautions and Warnings

These caution symbols point out important things to help ensure your assembly goes smoothly!

Beware the ESD monster!

The battery pack absolute maximum voltage is 7.5V. Minimum working voltage is about 3.1V.

CORES are fragile! Don't crush them.

CORES are small! Don't lose them.

Sometimes the term "Core64" might refer generally to "Core64c" which is the compact version. Core64 is specifically the larger or full-size version.

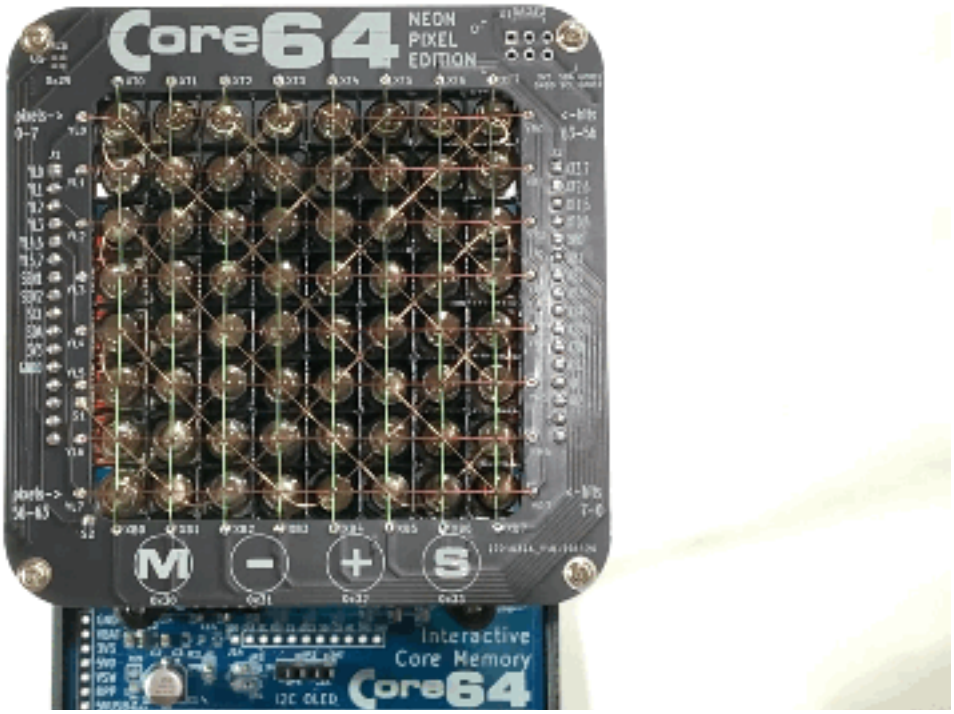
Some YouTube videos of the weaving process can be found here:
https://youtube.com/watch?v=IKOM7d1hxaw&list=PLgr0YZUR4CSVliIHI95UM3XHthRptkd2J

Specific videos are reference in the instructions of this assembly guide.

Do not place the Core64 circuit boards directly on a metal surface.

4. Introduction

Welcome to the assembly instructions for the Core64 and Core64c kits! This assembly guide covers all versions of the Core64 and Core64c kits. The pictures may not exactly match the kit you have, but the steps remain the same. Where there are significant differences in the kits there will callouts and notes to explain the differences.



What does Core64 do?

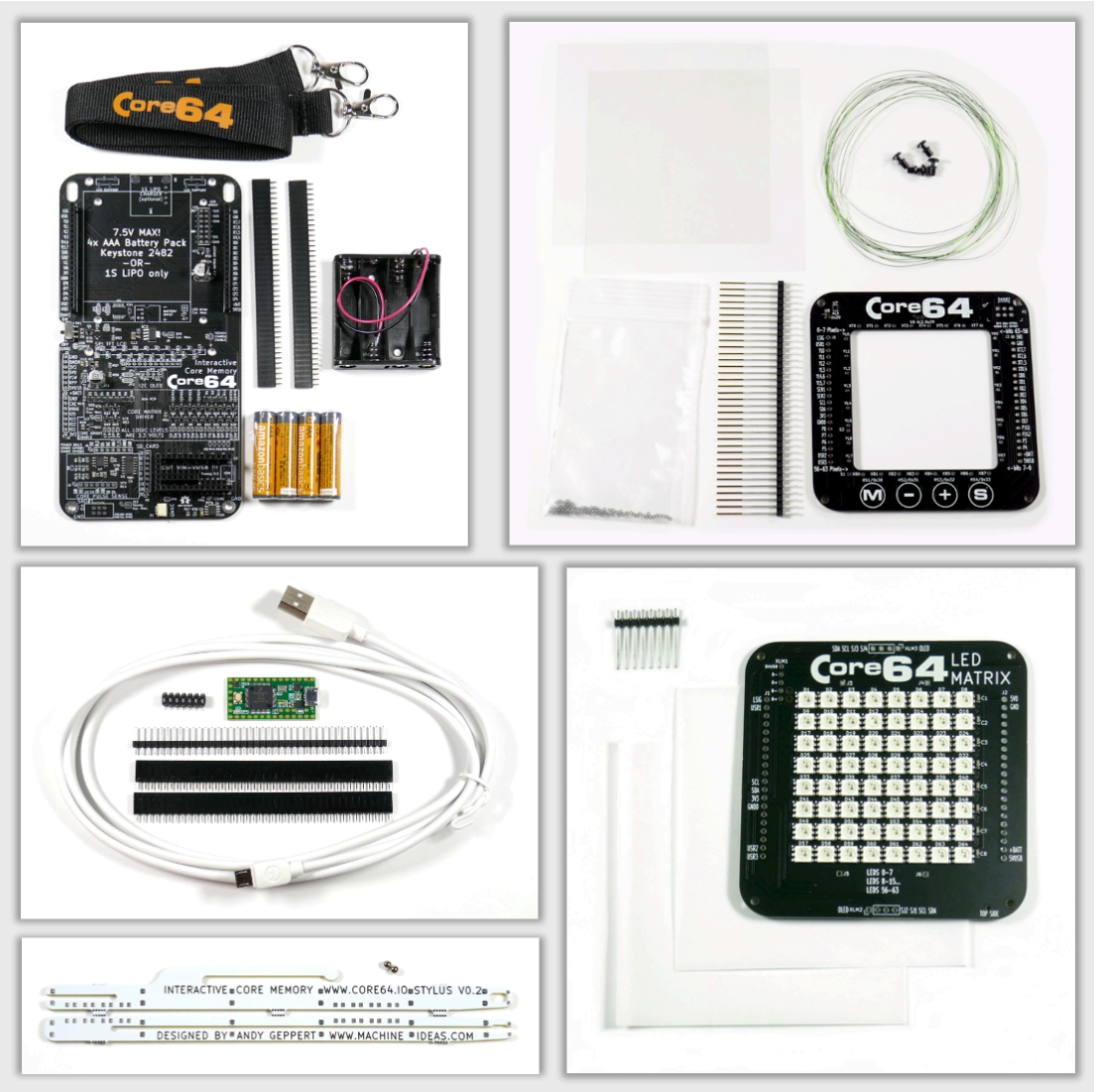
A layer of core memory on top of an LED Matrix enables you to use a magnet to draw in core memory and see the effect in real-time! This is Interactive Core Memory and the opportunity to learn how to use core memory down to the transistor level.

What comes in the Core64 kit?

With this kit YOU get to weave your very own 64 bits of core memory. You can use it as it is or modify the Arduino-based firmware and hack the Logic Board. The baseline functionality of the kit includes:

- 64 bits of core memory
- 64 RGB LED pixels
- An ambient light sensor (in the top left of the core board)
- Four Hall effect sensor "soft buttons" (bottom of the core board labeled M - + S)
- A Teensy 3.2 or Raspberry Pi Pico Arduino compatible microcontroller
- 4x "AAA" batteries and battery holder
- QWIIC Port for I2C compatible expansion
- SAO port for I2C + 2 GPIO expansion

In the image below, starting in the upper left, moving clockwise: Logic Board, Core Board, LED Matrix, Stylus, Teensy 3.2.



The five separate sub-assemblies which are included in the kit are:
1) The Logic Board is 90% assembled. You will install sockets and the battery pack.
2) The Core Board is 10% assembled. You will weave the core memory and install headers.
3) The LED Matrix is 90% assembled. You will install headers.
4) The Stylus is unassembled. Snap apart two boards, slide together, solder the joints.
5) The Teensy 3.2 requires you to install the headers.

The Teensy is pre-programmed with firmware - the latest release from https://github.com/ageppert/Core64/releases which will get you started with basic functionality. See the **Core64 Firmware Update Guide** for instructions on updating the Teensy.

What about Core64c?

The Core64 and Core64c kits are very similar. After assembly, they have the same stock functionality. Both kits use the same Core Memory Board and LED Matrix but the Logic Board and microcontroller are slightly different. The "c" is for "compact." The Core64c Logic Board is half the size of the Core64 Logic Board and fits completely behind the Core Board and LED Matrix.

The Core64 (through V0.6) uses a Teensy 3.2, but all versions of the Core64c use a Raspberry Pi Pico. This means the Core64c has slightly less spare IO available, but still enough for a couple of spare digital/analog pins, I2C, and SPI. Since the Pico has fewer IO pins, it drives the 20 transistors which control the core memory through shift registers instead of directly driving each transistor.

Both kits use MicroUSB connectors and have the same battery options - although the batteries can only be installed on the back/bottom side of the LED Matrix board in the Core64c. There is no room for them on the Core64c Logic Board.

A complete list and comparison of features is on the www.Core64.io site.

The Raspberry Pi Pico is not pre-programmed. See the **Core64 Firmware Update Guide** for instructions on programming it.

What else can I do with Core64?

You can add a variety of readily available hardware accessories such as:
Swap out the "AAA" battery pack for a 1S LiPo and USB charge manager.
SD Card Breakout board
LCD 3.2"
OLED monochrome
OLED color
Realtime Clock battery and crystal (only applies to Core64 with Teensy 3.2)
QWIIC port
SAO port
Your own ideas via 16 pins of GPIO, Analog in/out, IR in/out
Power access to the battery, 5V0, and 3V3 power rails
SAO compatible bling

Where can I get a kit?

The best place is https://www.Core64.io/

How do I assemble the Core64 kit?

This Assembly Guide is the place to start. I welcome feedback to improve it and correct any mistakes you find.

5. Tools Needed for Assembly

This kit requires some basic electronics tools. It is helpful to have a clear and bright workspace, and perhaps some magnification for your eyes. The cores are small, and you don't want to lose them!

TOOLS: PCB holder, soldering pencil, fume extractor, tip cleaner, tweezers, blunt tip plastic pointer, small flush-cut wire cutter, sharp hobby knife, two pair of flat-face pliers (or similar), continuity tester

SUPPLIES: Solder (1/32 or 1/16"), flux pen, isopropyl alcohol, Q-tips, Kimwipes or similar lint-free towel

If you are not already in the habit of using flux when soldering, you are missing one of the best tricks of the trade! Not just flux core solder, but a flux pen or flux paste. It's the secret to shiny solder joints that "just flow." But don't breathe it. Get a fume extractor and solder in a well-ventilated area.

OPTIONAL: Ruler, scissors, magnifier, flux remover, task light

Pause and take a deep breath! Proceed slowly, be careful, and make it count! I want you to be happy with your results, and I know this is going to be a challenging kit if it is your first time weaving core memory. Please don't rush it. Take frequent breaks. I do NOT recommend completing it in one sitting. Gentle persistence will get you through the weaving process.

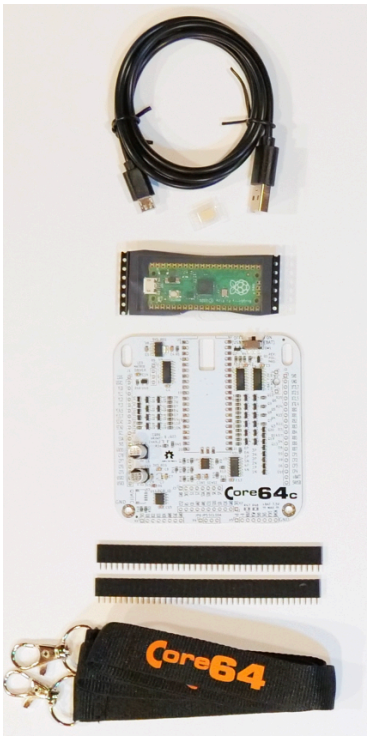
6. Logic Board Assembly

STEP 1: Gather the Components

The Logic Board needs the sockets installed to receive the Core Board and LED Matrix. You also have the option to provide power to the system from the Logic Board or the LED Matrix with Core64. You can set aside the lanyard for the final assembly steps.

Core64

Core64c



The picture shown above (Core64 version, not Core64c) has the header sockets installed for both the Core Board and the Teensy - as they shipped with the Beta Kit (you're welcome!). Since they are already installed, your Beta Kit does not have the two 20 pin sockets in this part of the kit, but there are two in the Teensy kit which you can use for optional expansion later.

If the headers are already installed in the [beta] kit that shipped to you, jump to the step regarding battery pack installation options.

The SAO 2x3 socket is not shown in the picture above, but it is included in the Beta Kit in the battery pack. It can be installed on the Logic Board in the lower left corner, or on the Core Board (upper right corner). It is optional and opens the door to all sorts of fun on Tindie. It's yet another I2C port and includes power and two GPIO pins. Note that the SAO socket is KEYED and needs to be installed with the key feature up.

Before you solder the power to the board, carefully slide the power switch to the OFF (USB) position. Avoid pushing the switch up and away from the PCB or it may bend upward.

STEP 2: Cut and install sockets for the Core Board

The two socket headers are each 40pins in length. You will need to cut each one down so you can get two complete 20pin sockets, because the cut ends up being through the middle of the 21st pin, making it unusable. This will leave you

with two 19pin lengths of sockets which you can use for expansion options later. Install the two 20pin sockets from the top of the Logic Board and trim the pins on the backside before you solder them in place.

Try to make the solder joints nice and smooth on the back side so nothing will scratch or snag on the back. If you initially solder each pin flush, you can come back and give them a quick touch of solder to make a shiny domed top, so they aren't sharp.

The sockets for the Teensy are included in the Teensy Kit. Instructions for installing those are in the Teensy Assembly Section.

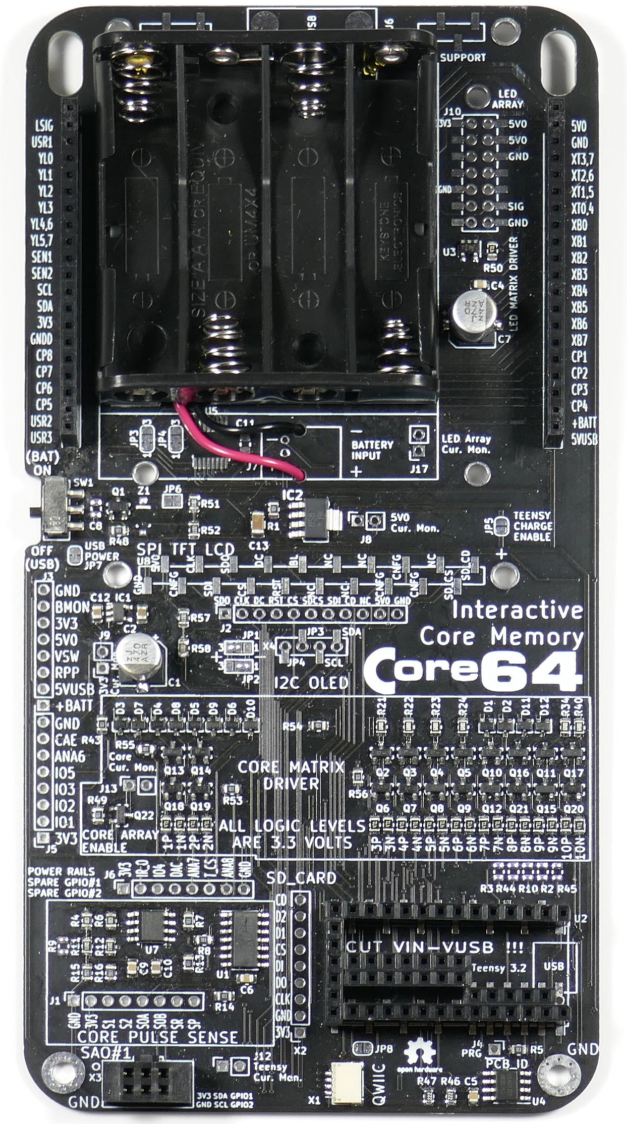
You can now insert the SAO socket into the Logic Board if that is where you would like to install it. Or, set it aside and decide later if you'd rather install it on the Core Board at the top.

STEP 3: Battery pack installation options (skip this step with Core64c)

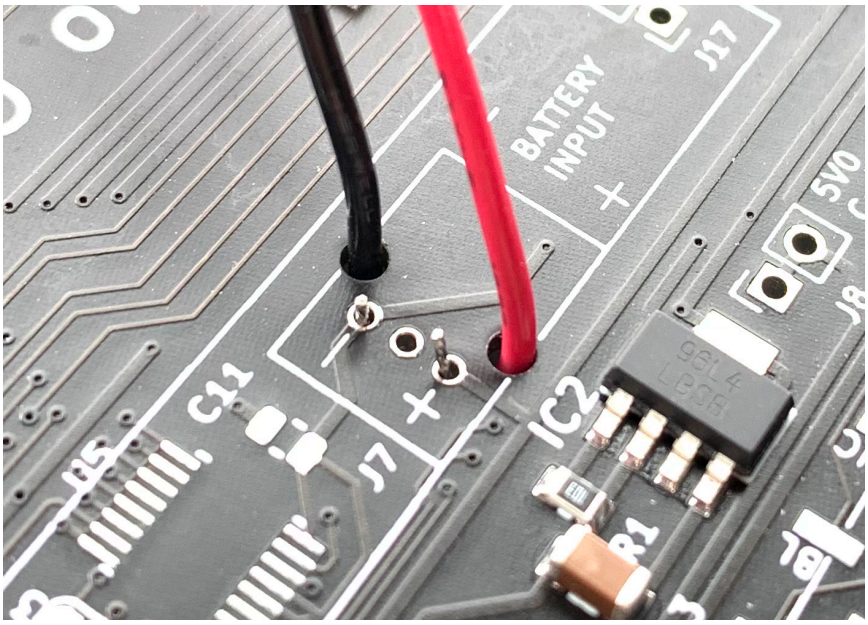
The battery pack can be installed on the Core64 Logic Board, but not on the Core64c Logic Board. With the Core64c, the battery must be installed on the backside of the LED Matrix Board.

The included battery pack can be installed on either the Logic Board or the LED Matrix. I recommend the Logic Board, so the battery cells stay in place slightly better with gravity. The instructions for installing the battery pack to the Logic Board are here, and the instructions for installing the Battery Pack on the LED Matrix are in the LED Matrix Assembly Section.

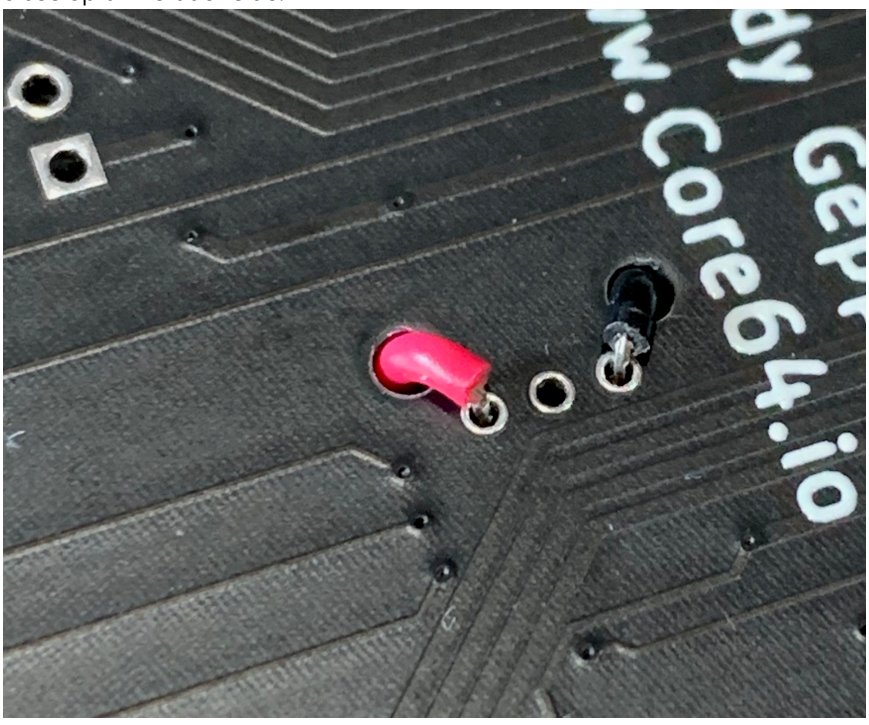
The back side of the battery pack has double-sided foam tape installed for securing it to the Logic Board. The position is shown on the silk screen, and shortened wires are shown here in the image here.



Insert the wires with the insulation through the two blank holes (see above) and then turn the wires 180° back up through the board and route the stripped ends through the top side. This requires cutting down the overall wire length and re-stripping the ends. Solder them on the top side in the "+" and "-" holes. This provides a strain relief for the wires. Close up of the top side:



Close up of the back side:



If you'd rather not make use of the strain relief feature, or you just don't want the wires to be exposed on the backside... You can just solder them straight down into the holes from the top side.

This completes the Logic Board assembly.

7. Teensy® 3.2 and Pico Assembly

STEP 1: RASPBERRY PI PICO or [BYO Microcontroller] PICO W

The Pico is used in all versions of the Core64c.
The Pico is used in the Core64 starting with Version 0.7.

The Pico does not have firmware pre-installed. Download it from here: https://github.com/ageppert/Core64/releases/

Install the firmware after connecting the Pico to your computer with a MicroUSB cable. Drag-n-drop the Core64_Firmare_[Version].hex onto the Pico USB Memory device which shows up on your desktop or File Explorer. After a reboot of the Pico, the LED on the Pico should blink in a heartbeat pattern. If you'd like more detailed instructions, see the Core64 Firmware Update Guide.

Assembly of the Pico to the Logic Board is very straightforward. Simply align the Pico on the Logic Board with the USB connector at the outer edge of the Logic Board. You can use thru-hole pins from header sockets or pins in opposite corners of the Pico to keep it aligned during soldering. Solder the castellated notches on the edge of the Pico to the Logic Board.

That's it! No more steps for the Pico assembly.

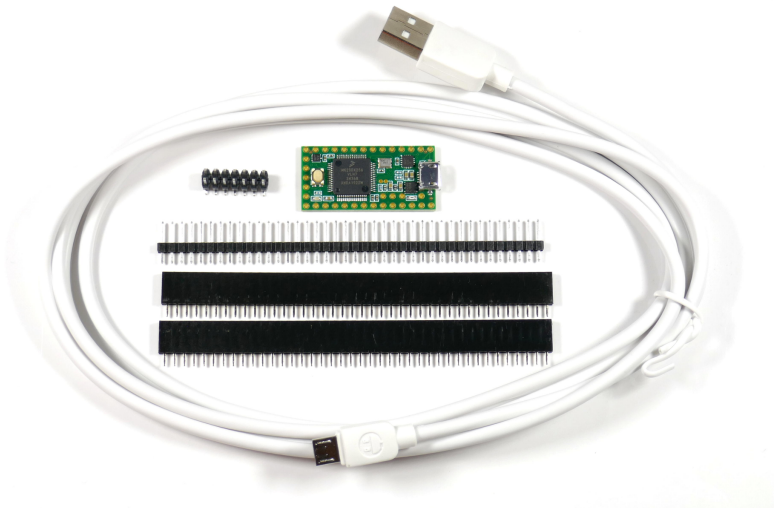
STEP 1: Teensy® 3.2

The Teensy® 3.2 is used with Core64 Versions 0.4 through 0.6.
The Teensy® 3.2 is not used with Core64c.

> ⚠ You must CAREFULLY cut a trace on the back of the Teensy® board prior to assembly! See Step 2.

This part of the process is made up of cutting headers to length, filing, or sanding the ends square, and a bunch of soldering. When you are done, you will have a few pins and sockets left over to use for other optional features. Read through this whole section to see where you are headed, which is illustrated in the last image. The lengths of the pin headers will be different initially and will require some trimming. This will help assure the Teensy® 3.2 fits well.

Gather the Components

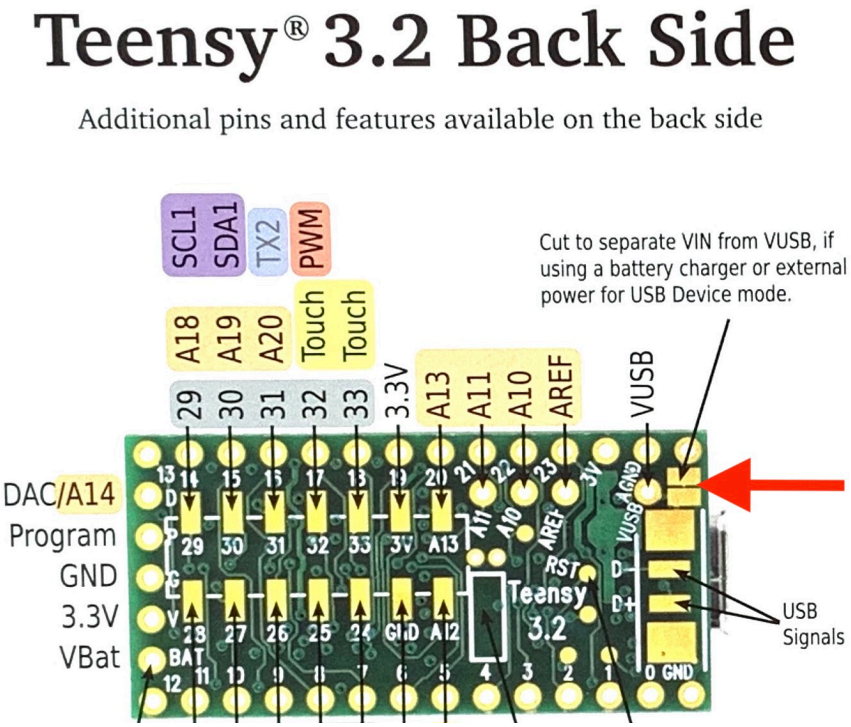


An OLED Display option to consider

There are several optional OLED screens you can choose to add to the Core64 (see the Core64 Hacker Guide). Some of those screens can be installed in the middle area of the Logic Board. But one option is the 128x32 pixel Blue OLED TeensyView made by Sparkfun. If you choose that option, you will not want to install the Core64 headers around the perimeter of the Teensy®. Instead, you will want to purchase and install long pin female socket headers such as the Teensy® Header Kit.

STEP 2: Cut the VIN-VUSB trace on the back of the Teensy®

You may have noticed a warning sticker, or two... Here's the spot marked by the red arrow shown with reference to the back of the Teensy® info card with the official explanation:

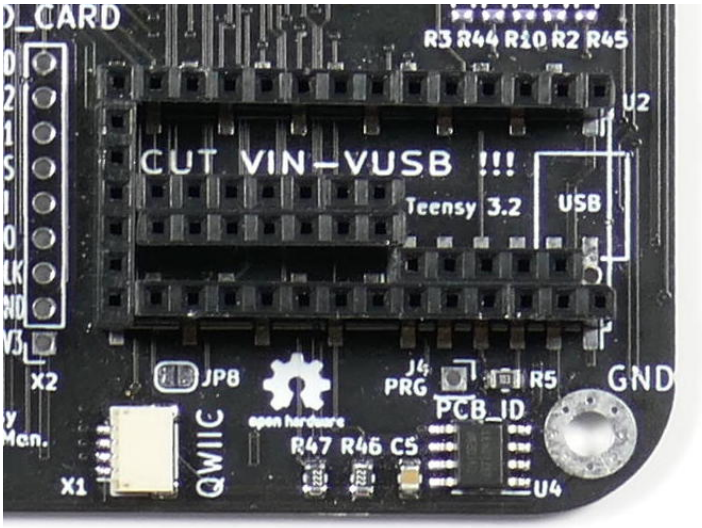


Be careful to cut only this trace, on this visible layer. Do not cut too deep or you could cut an inner trace below this one. If you do, there is a forum post at PJRC on how to overcome the cutting of the inner trace. After you cut the trace, measure for continuity between the two adjacent pads. Please be sure you have cleanly separated those two pads. You do not want battery pack voltage and your USB port 5V to mix. Cutting this trace ensures they do not mix.

STEP 3: Install Teensy® female sockets on the Logic Board

If you bought a Beta Kit, this step is already done for you. And you've got an extra set of sockets for whatever you'd like to use them in. You're welcome!

Otherwise, cut, trim, sand, file... and repeat until all the Teensy® receptacle pins are filled like this:



The most important thing is to keep the sockets perpendicular to the board and each other so the stay in alignment. This will make it much easier to install the Teensy®. It also provides an alignment fixture for soldering the headers to the perimeter of the Teensy®. You can export an STL file of this jig I designed in OnShape to use to ensure the sockets all fit together smoothly, and have 90° alignments. (Print with the version number face down.)

> ⚠ If you use the fixture, make sure the headers fit smoothly into the fixture without any friction. If you must force them in, and you try to pull the header out by the pins, you'll end up pulling the pin out of the header socket and probably ruin it.

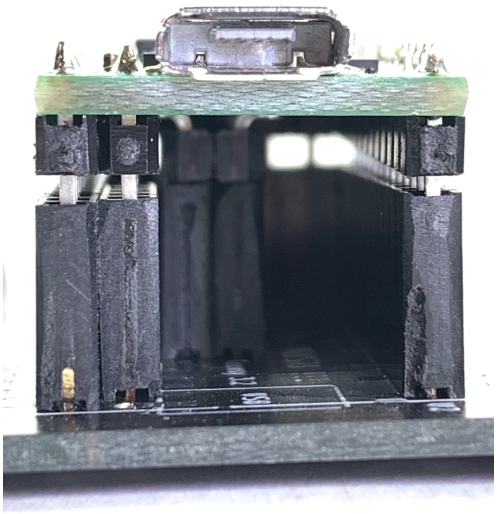
I strongly recommend trimming all the leads on the backside for these socket headers and making smooth solder joints, so the Logic Board does not scratch or snag anything it is placed on or against (like your shirt).

STEP 4: Install the male headers to the Teensy®

Did you cut the VIN-VUSB trace on the bottom of the Teensy® yet? If not, go back to Step 2 please!

> ⚠ You must CAREFULLY cut a trace on the back of the Teensy® board prior to assembly! See Step 2.

Before we proceed, here is a preview of how all the headers are going to stack up for the Teensy®. Note how the center SMD header is offset downward because it is SMD. But make sure you install the outer thru-hole headers flush with the bottom of the Teensy. The helps ensure a solid right-angle connection to the PCB, and it provides a gap around the outside that you can use to separate the assembly Teensy from the socket if needed later.



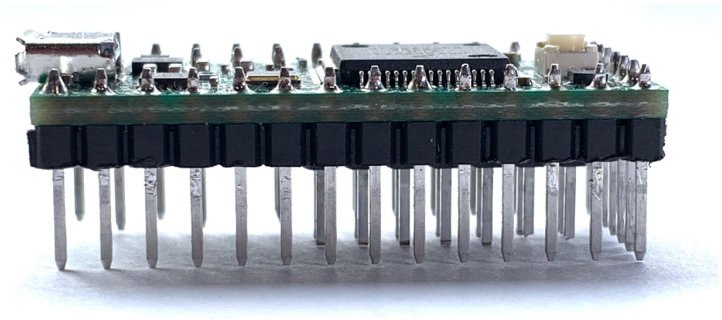
Start with the innermost SMD 2x7 header. Alignment is critical, so take your time with this and get it right. Center it as carefully as you can in the pads, in both directions. Start by soldering just one pad and tweak the position of the whole header ONLY when you have the solder pencil on that pad. If you try to rotate the header and the joint is solid, you will shear the pad off the board.

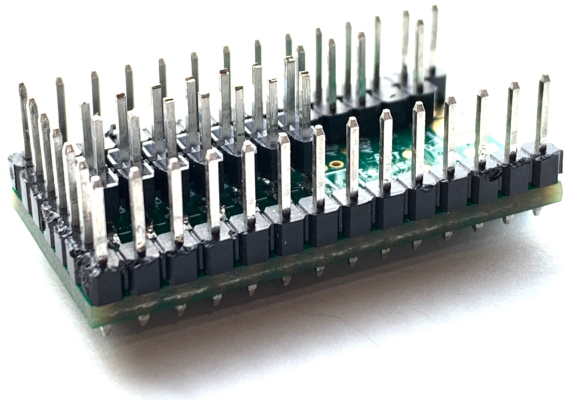
> ⚠ Do not be tempted to insert the Teensy® into the female sockets until you have securely solder ALL 14 of the 2x7 SMD header pins to the Teensy®. There is a very high risk of tearing off the pads when you go to pull the Teensy® out. You can obtain a replacement Teensy® 3.2 from Digi-Key or another distributor.

Once you are satisfied with the alignment, proceed to solder the opposite corner solder pad.

If the alignment is still perfect, then proceed to solder the rest of the pads. If it's not perfect, reheat the first two joints and tweak it until it is. I'm not trying to be overbearing about this alignment. I know you can get it right and it really makes the rest of this go together easier if you focus on this step.

Now cut down the center 2x7 pins so they will be the same length as the perimeter headers when they are installed. All the pins will end up having the same length when resting on the tips after they are all soldered in:



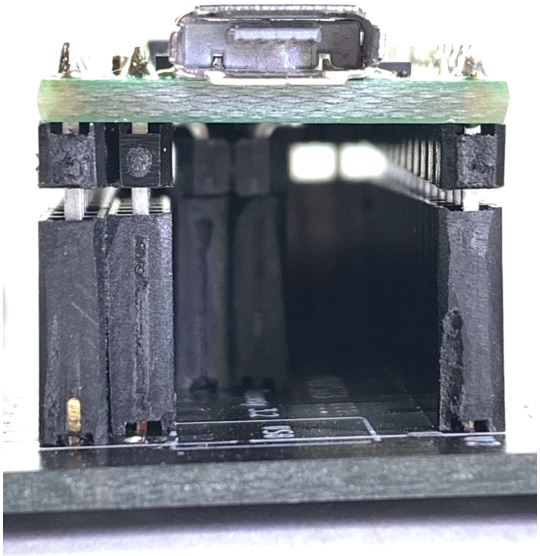


Clean the flux from the 2x7 header solder pads now because it will be hard to access after the next step.

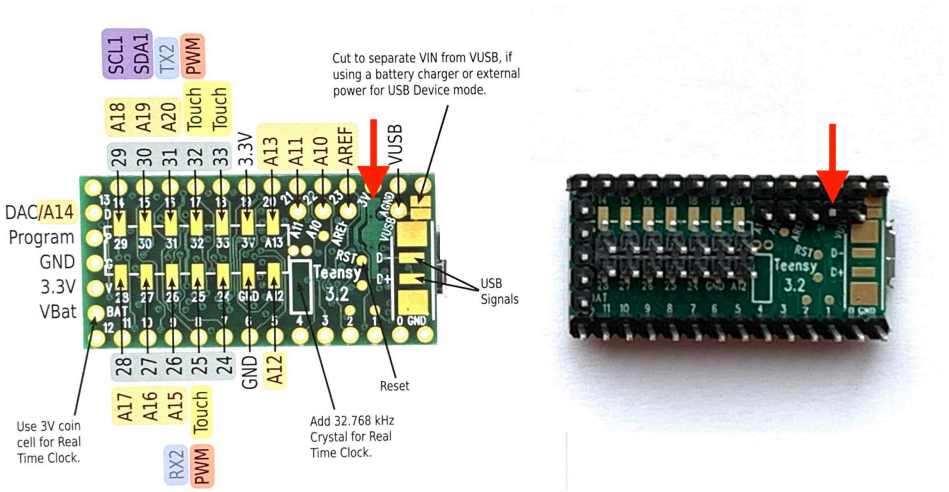
The long strip of header pins needs to be cut into several shorter lengths to populate all the headers around the perimeter of the Teensy® board. When you install the headers, make sure they are perpendicular to the board. A good way to do this is to insert the Teensy with the headers loosely installed into the female sockets of the Logic Board. The Logic Board can hold everything in alignment as you work your way around the perimeter of the Teensy®, soldering all the headers.

When you install the not-yet-soldered Teensy®/Headers in the Logic Board, you will need to slide the perimeter headers up towards the board so they are not pushed all the way into the sockets.

Leaving a gap between the sockets and plastic of the headers is important because it provides a place to insert a screwdriver or similar lever to gently pry the Teensy out of the sockets.

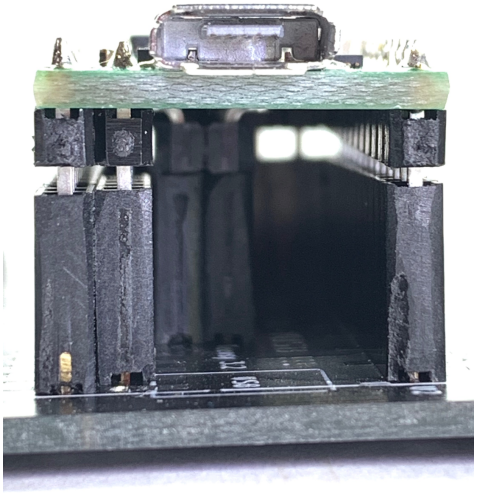


There is one pin header position that needs to be skipped or clipped down because there is not a hole in the Teensy® board for it. It is shown with the red arrow:



> ⚠ Leaving a gap between the header and socket on the perimeter is important in order to make it easier to remove the Teensy® from the Logic Board. You will need to insert a flat blade screw drive and gently pry between the top of the socket and bottom of the header, working your way around the perimeter evenly, to extract the Teensy®. For the sake of this assembly step, you can just leave the Teensy® in after you solder it. There is no need to remove it.

The center SMD 2x7 header will cause the whole Teensy® board to sit up a little higher than it would with just the straight perimeter headers. Here it is installed:



Clean the flux from the header solder joints on the top of the Teensy®.
Later, if you decide you'd like a lower profile installation, and everything is confirmed working, you could remove the sockets and solder the Teensy® headers directly to the Logic Board. I don't recommend doing that because if you must remove it to troubleshoot or want to repurpose the Teensy® for something else, it's a bunch of extra work to de-solder it. You also risk damaging the boards.

The Teensy® assembly process is complete!

8. LED Matrix Assembly

Version Differences

Beta Kits (early 2021) came with the V0.2 LED MATRIX.
Pre-Production Kits (late 2021 & early 2022) come with the V0.3 LED MATRIX. These omit:
The QWIIC connector (you can add it yourself JST SM04B-SRSS-TB from Digi-Key or similar)

There is still a QWIIC connector on the Logic Board.

Components

The LED Matrix assembly is very simple. There are three items in this part of the kit:

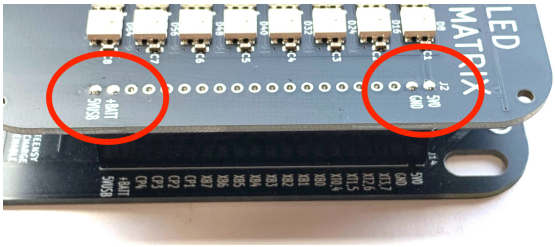
- LED Matrix Board,
- 8-pin header,
- Diffuser sheets.
- Later kits have a diffuser grid included as well.

STEP 1: Cut the header into four pairs

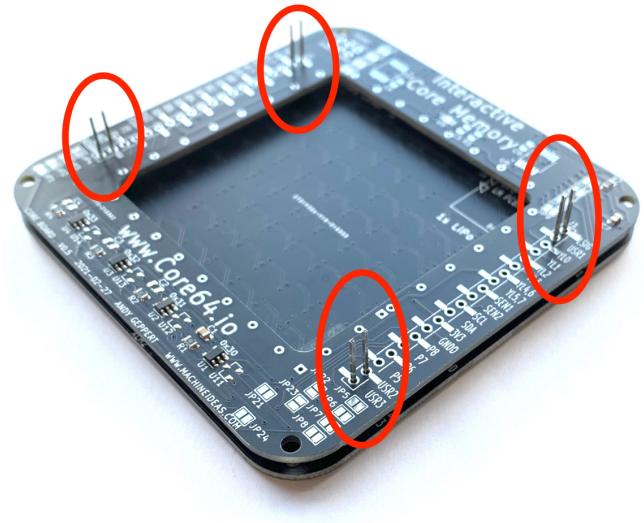
The 8-pin header needs to be cut into four pairs of pins. Each pair of header pins will go at each end of the 20-pin rows on the left and right edges of the LED Matrix. The middle 16 pins will remain open so the Core Board can slide through those holes and connect independently to the Logic Board.

STEP 2: Solder the headers

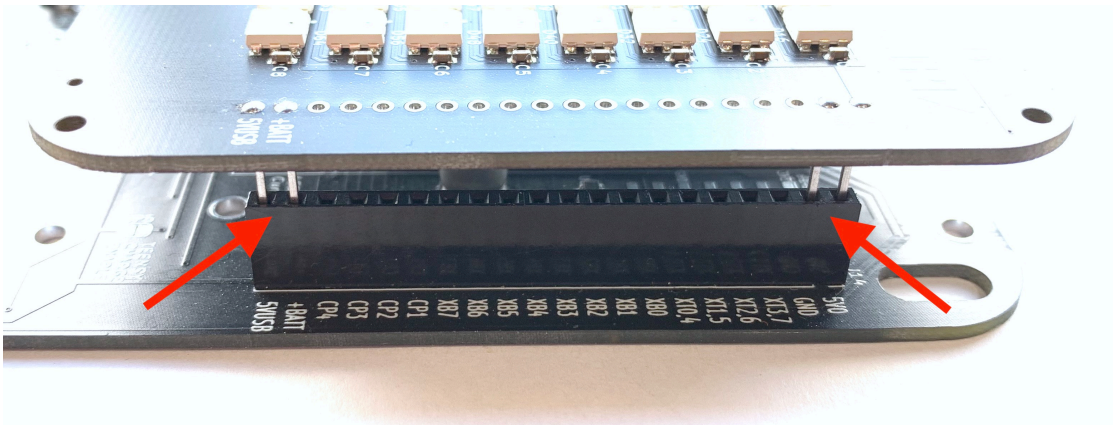
Trim the short end of the header so it barely sticks through the board. Flush is preferred. If you initially solder each pin flush with the top of the board, you can come back and give them a quick touch of flux and solder to make a nice domed top, so they aren't sharp. Like this:



To hold the header pins in place, you can use the Core Board as an alignment fixture.



You can also use the backside of the Logic Board, or the Logic Board sockets if you have those installed already.



Whichever method you choose, the goal is to keep the headers perpendicular to the bottom of the LED Matrix board. Final assembly position is like this:

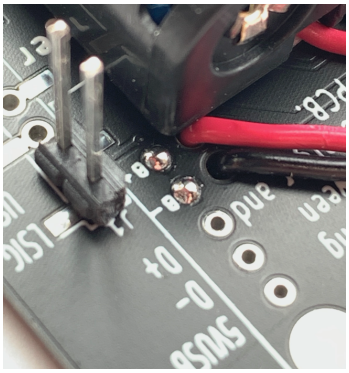
Yes, that black wire is a bodge wire on the Beta Kits (V0.2 LED MATRIX. I failed to route the Digital Ground wire all the way to the header row. This path supports optional I2C-based accessories at the QWIIC port and the 4-pin header holes at the top and bottom edge.

After soldering, clean off any flux with isopropyl alcohol.

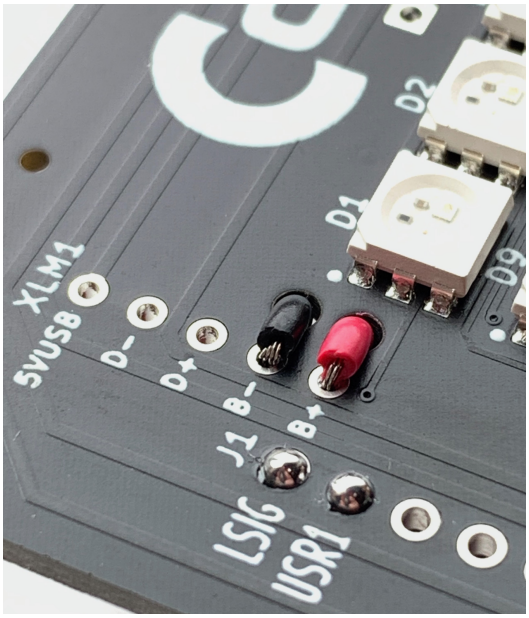
STEP 3: Battery Pack Installation

The Core64 can accept the battery pack on the top of the logic board or the back of the LED Matrix.
The Core64c can ONLY accept the battery pack on the back of the LED Matrix.

For the Core64, I recommend putting the battery pack on the Core64 Logic Board, and those instructions are provided in the Logic Board Assembly Section.
If you choose to install them on the LED Matrix (and you must for Core64c), the battery cells may fall out of the holder slightly since they are not held in by gravity. You may need to secure them with tape, depending the brand of cells you buy.
The battery pack includes double-sided tape so it can stick to the board. Install it in the position bounded by the four inner triangle marks denoted "Battery Corner" on the silkscreen. The insulated wires are routed through two small non-plated holes (strain relief) next to the B- and B+ silkscreen at the upper right corner on the backside of the board. Then route the wires back through the B- and B+ holes from the LED side.
The solder connection is made on the battery pack side shown here:



Here is what the wires look like on the LED side:



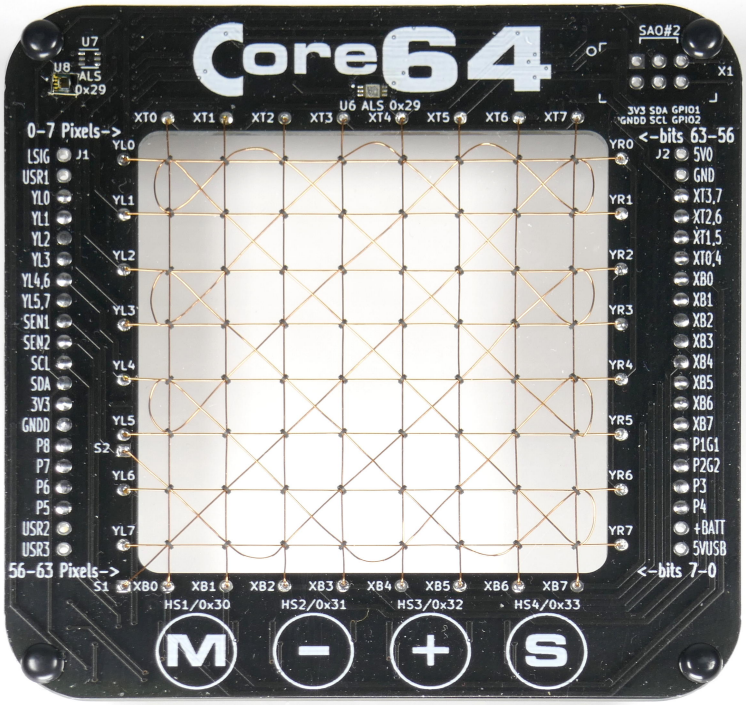
At some point you'll probably notice the Core Board has 8 pins which are labeled, but not used or connected to anything. They are the top and bottom pairs of holes on both the left and right edges of the board. From left-to-right, top-to-bottom: LSIG/USR1, 5V0/GND, USR2/USR3, +BATT/5VUSB. These pins are active in the Logic Board and LED Matrix, but unused on the Core Board. They are labeled on the Core Board for reference/expansion if you come up with something clever.

LED Matrix assembly is complete for now. Later, in the Final Assembly chapter, you will trim the header pin lengths to match the Core Board header pin lengths.

You can power things up right now (Teensy® + Logic Board + LED Matrix) and you should see all the LEDs illuminated in blue (or slowly changing color) at a fixed brightness. The LEDs may start to cycle through colors in later versions of firmware. The orange LED on the Teensy may blink or be on. Either batteries or USB will work as a power source. With USB the switch needs to be in the down position, with batteries the switch needs to be in the up position.

9. Core Board Assembly

This is the end goal for Core Board Assembly (front side):



This is a challenging assembly process - by far the most challenging part of the kit. But it is the most rewarding part of the assembly process too!

The first several steps are relatively easy, and the last steps are relatively easy. Somewhere in the middle is the delicate process of weaving. Just take it slow - do not rush it. I hope the techniques I provide will make the weaving go smoothly for you. I'm going to remind you to go slowly and be gentle about 10 more times before we're done. If you get frustrated at any point, stop. Take a break and let me know what step you are struggling with via Discord.

At some point you'll notice the Core Board has 8 pins which are labeled, but not used or connected to anything. They are the top and bottom pairs of holes on both the left and right edges of the board. From left-to-right, top-to-bottom: LSIG/USR1, 5V0/GND, USR2/USR3, +BATT/5VUSB. Most of these pins are active in the Logic Board and LED Matrix, but unused on the Core Board. They are labeled on the Core Board for reference/expansion if you come up with something clever.

STEP 1: Prepare your workspace for success

Whether this project looks daunting, easy, or somewhere in between, these tips and techniques will help you be successful. Start with a clean and bright work area so you can find the cores when you drop them... Set up your PCB holder and soldering related tools.
Now is a great time to tune into some good music or a podcast!

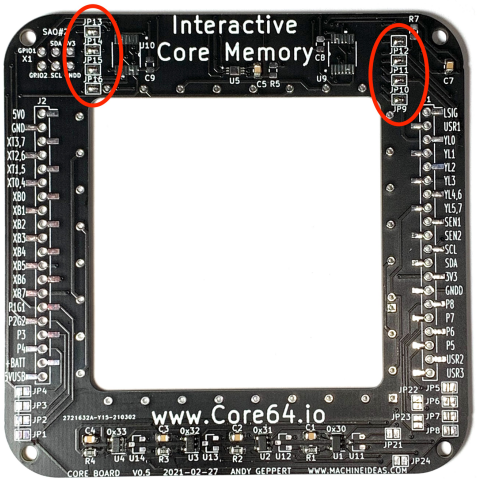
STEP 2: Gather the materials and clean the wire

In the kit you will find 1x Core Board, 70±2 Ferrite Cores, 100 inches (2.5 meters) of magnet wire (insulated annealed copper 0.2mm / .008in / 32AWG), 4 plastic rivets, 2 or 3 screen protectors, a tall 36-pin header, and in some kits the SAO 2x3 Socket is included here (otherwise it is in the Logic Board kit). The top of the core board is shown below. Wire and board color may be different than shown.

Be careful not to kink the wire when handling it. Any little kink or bump or bend in the wire makes it difficult to thread through the cores. The Y-wires are a little more forgiving, but the X-wires need to be S-M-O-O-T-H. The sense wire is much easier to pull if it is smooth as well.

STEP 3: Solder Jumper Configuration (back side)

To configure this core board to work as a single plane, 8 solder jumpers require soldering. They are JP9-16 on the backside, near the upper left and right:



The other solder jumpers and unpopulated components are designed to allow a stack of up to 8 core planes. I have not tested that yet, so it's not supported. There are more notes in the schematic if you are curious.
https://github.com/ageppert/Core64/blob/master/Schematics/Core64%20CB%20v0.5%202021-02-28.pdf

STEP 4: Cut the X and Y Wires to Length

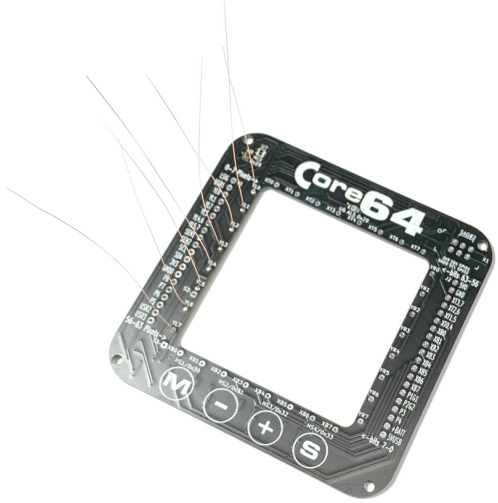
Straighten and clean the wire with isopropyl alcohol and a lint free wipe. Making sure the wire is clean and mostly straight will make the weaving process easier. I pinch the damp cloth and wire between two fingers and pull the wire

through gently, adjusting pressure of my fingers so the wire comes out mostly straight. If the ends are damaged, cut off 1-2cm so the end is clean and straight.
Cut a total of 16 pieces of wire each 8-9cm long. The Core Board is 8.5cm square for reference, so you can cut the wires to the same length as the Core Board is wide. This will given you 8 X-wires and 8 Y-wires.
This leaves the remaining long piece of wire for the final sense wire weaving steps after X and Y wires are woven.

STEP 5: Install the Horizontal Row (Y) Wires and Cores

Place the board upside down. Put a touch of flux on all 34 X-Y-Sense wire pads. Apply the flux sparingly so it doesn't wick through the pad hole. If flux gets onto the wire and the cores, it makes them sticky and a bit more difficult to work with.
Place a gentle curved 90° bend about 1cm from the end of 8 wires. Don't make it a sharp bend which will weaken the wire. Insert the wires from the backside through YL0 to YL7 so they hang down and are stopped by the bend. Skip the S1 and S2 positions - those are for the sense wire which is installed after the X-Y weave is complete. Solder the 8 wires in place on the back side of the board. You do not need to dwell on the solder joints at this time. In later steps we will come back and heat the joints and apply gentle tension which will soften the enamel and burn it out, leaving a good connection between the wires and the pad.

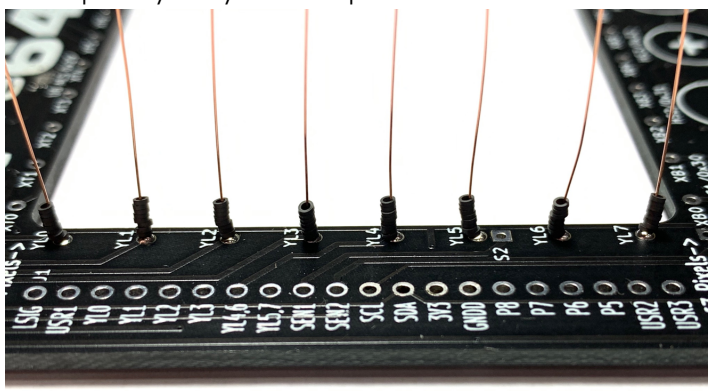
Flip the board top-up and arrange all the wires so they are standing straight up and are not twisted against each other. This makes it easier to slide the cores on.



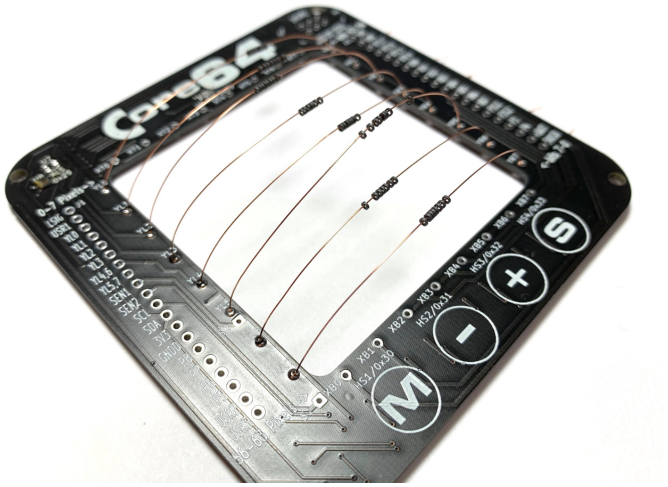
> ⚠ There are 70±2 cores included so you can lose only a few... be careful! If one disappears there is a 99% chance you will never see it again. I use some tweezers to pick them up and place them. Make sure you have a balanced grip on each side of the core so that your gentle tweezer pressure doesn't cause them to fly out of the tweezers.

Pouring the cores out of the bag onto a soft surface is helpful to prevent them from scattering. A paper towel or microfiber cloth is a good choice.

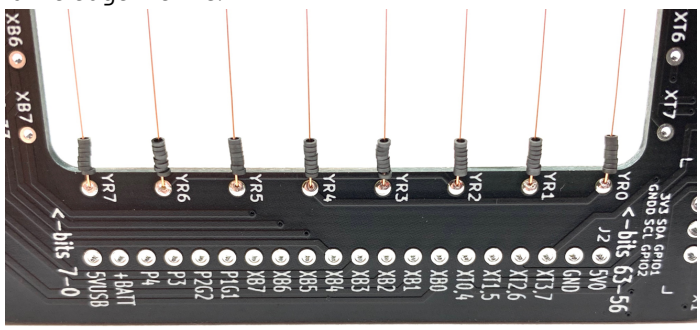
Using some tweezers, pick up the cores and slide 8 of them down onto each of the 8 wires from the top side. They will stack up nicely and you can inspect that all the stacks are the same height to confirm there are 8 on each wire.



Gently arc the wires over to the opposite side and insert them into the YR0-7 holes. Slide the cores up to the middle before you pull the wires tighter. The top of the wire arch can be mostly flat/level so the cores stay in place.

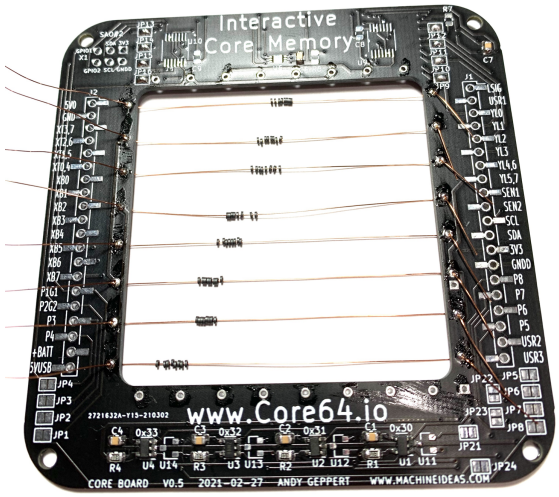


Now you can gently pull the wires through from the bottom of the YR0-9 side to flatten them out. As you do this, make sure the cores closest to the ends don't become trapped/crushed between the wire and the board. They can be close to the edge like this:



Flip the board over and solder the wires on the back side at the YR0-7 pads. You don't need to dwell long with these solder joints because we will come back to them after all of the weaving is complete. Use just enough tension to straighten the wires. Final tensioning will be done after all the weaving is completed.
Important note about tensioning: I was using a curved nose hemostat initially, and it was way too easy to apply too much tension and break the wires. I have switched to using tweezers with smooth gripper faces, which is effective at being an automatic tension limiter.

Congratulations! Your abacus is complete!

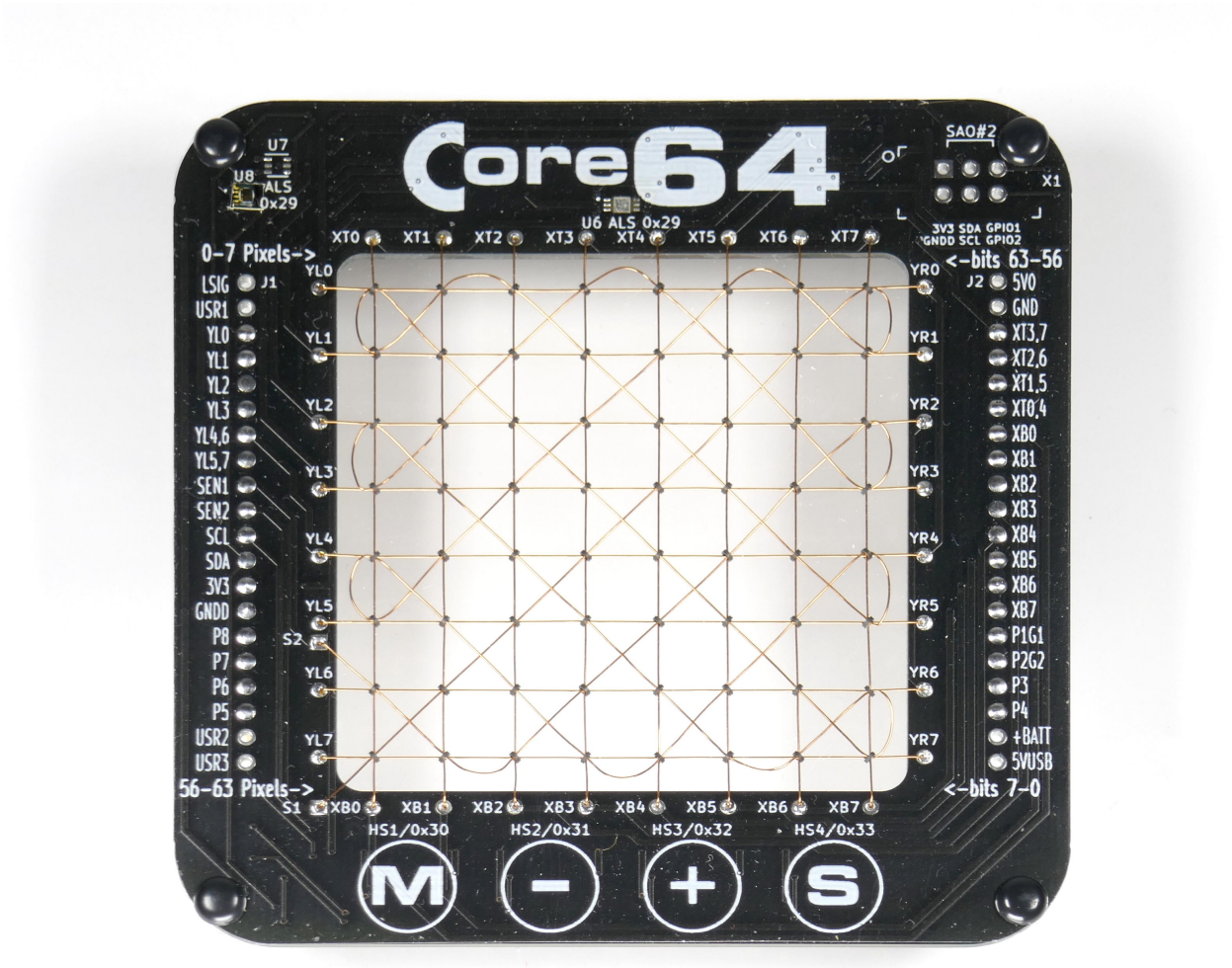


STEP 6: Weave the Vertical (X) Wires

The second and last batch of 8 wires is used next. Clean and straight, with a tiny little bend at the end is my preference. The bend is subtle, but SOOO helpful! Here is what it looks like, shown as the bend passes through the final core in the first column.

Check out this video showing and explaining the "bent wire" technique: https://youtu.be/PfxXD_jm978
To begin weaving the first column, slide 7 cores on each Y wire out of your way, and leave one column of cores to work with. All the cores need to be installed with alternating 45° offsets from the wires, from top to bottom, and left to right.

This pattern enables optimizations in the wiring and driving circuitry - it was figured out decades ago. **The outer corner cores will all end up having their central axes point inward to the center of the core plane.** This alternating pattern also makes it easy to thread the sense wire diagonally. If this isn't making sense, here is a visual reminder of how all the cores are arranged:



Notice how all the cores have alternating arrangements, which sets up to allow the single continuous sense wire to wind back and forth through all 64 cores later in this process.

> ⚠ It's way too easy to get focused on getting the wire through the core... and then fail to notice the orientation of the core. Keep double checking your work so you don't end up getting the column woven, only to find some cores in the wrong orientation.

Start at the lower left corner, and follow the pattern shown above. Gently nudge the wire through the cores from the bottom row, proceeding upward. Twist the wire back and forth 180° to make it easier to enter the next core in the column, depending on the orientation that core needs to be at. You don't have to be concerned with whether or not the vertical/horizontal wires are on the top/bottom of each other when they go through a core. I try to keep my weaving consistent "just cuz" but it really doesn't matter.

The further you get into the weaving process, the more challenging it can be to keep things lined up squarely. Be careful, try not to stretch the wires. They can handle a little bit, but you'll have much better results if you gently push and/or pull the wires during the weaving. Sometimes a core will bind and lock against the wires because it is at a 45° angle to both wires. When this happens, use a tweezers with each leg straddling the wires and nudge the core in the right direction to unlock the intersection joint.

After you complete a column, leave the wire flat on top of the board, roughly centered vertically. Check to make sure your alternating core orientations are correct.

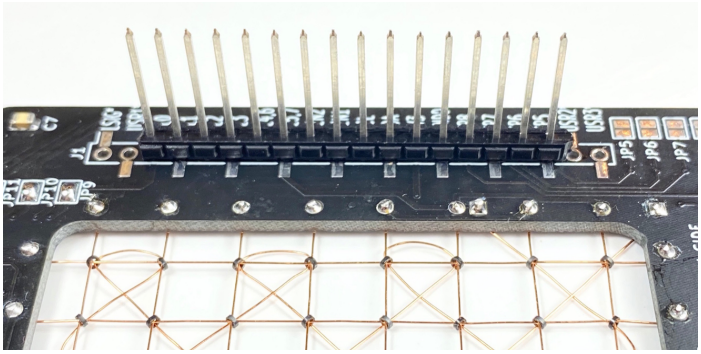
Take a break. This is the most challenging part of the process. It's tedious, and if you rush it, things can go bad in a hurry. Work through this vertical wire weaving carefully 7 more times and you'll be through the worst of it.
Once you have the weave together and aligned, you can carefully insert the ends of each vertical wire into the associated column through-hole. Try not to create a sharp bend or kink in the wire between the array and the through-hole. Slow. Careful. Gentle. You get the idea... Here's the technique I use: https://youtu.be/vPc71MGQkeA

Next, flip the board upside down again, and gently pull the vertical wires straight. Solder all of the vertical wires into place. No need to dwell on the solder joint just yet.

Now we will tension and align the array. Once you have confirmed the core pattern is correct, you can dwell a little longer on each solder joint to make sure the enamel is burned away. Apply gentle tension to the wire with a tweezers while heating the connection. Dwell for 4-5 seconds and remove the soldering tip - but leave the tension for 5 more seconds so the solder joint can solidify before you remove the tension. Go around the entire board perimeter and treat all 32 solder connections like this at least once to get good continuity at the solder joint. Here is a video of the techniques I use: https://youtu.be/shIGhJ2QlZo

The array should be coming together nicely and squaring up like this:

Do NOT cut the wires yet, even though they are shown as cut in the next image.
If you see solder joints where the solder is not wetting out and flowing on to the wire, you probably don't have a good solder joint. On the backside of the Core Board, where all of your wire weaving solder joints are, you ultimately want to see each joint look like this, where the solder flows up on the wire.



Now is a great time for a continuity check. Video of the technique: https://youtu.be/t-OxUjbSRk8
Use a multimeter to ensure continuity is solid. Measure each wire by putting the multimeter probe points into the PCB PAD at the end of each wire. In other words, make sure you are measuring for continuity through this entire circuit path: Solder Pad -> Solder Joint -> Wire -> Solder Joint -> Solder Pad. If any of the wires do not show good continuity, gently tension the wire and reflow the solder (add a touch of flux first) at each end of the wire to make a good connection through the enamel.
A nice taught (not tight, just taught) array will not only look nice, but it will help making threading the sense wire easier.
Do NOT cut the excess off the X/Y wires yet.
At this point, you are through the worst of the weaving process! I think the sense wire is easier to manage. You are on the home stretch!

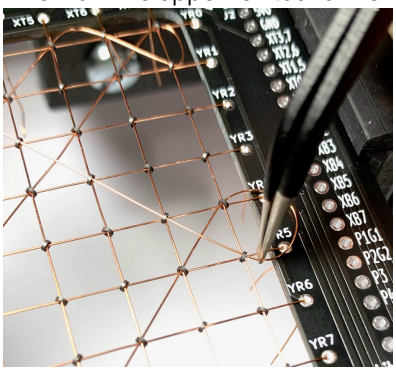
STEP 7: Weave the Sense Wire (the last one!)

Using the third and final piece of wire you cut at the beginning of this process, start by inserting the sense wire from outside the bounds of the plane into the core in the upper right corner. You will want the tip as straight as possible. Gently push and pull the wire through the diagonal cores toward the lower left corner. When you get the tip of the wire to the lower left corner, insert it through the S1 pad hole, letting it extend about 3/4" or 15 mm through the board out the bottom side. Don't solder it right now.
Here is a video where I start pulling the wire from the lower left. The technique varies slightly but ends up the same. https://youtu.be/LnRh11oBx6Q (ignore the weaving fixture, it wasn't that useful).

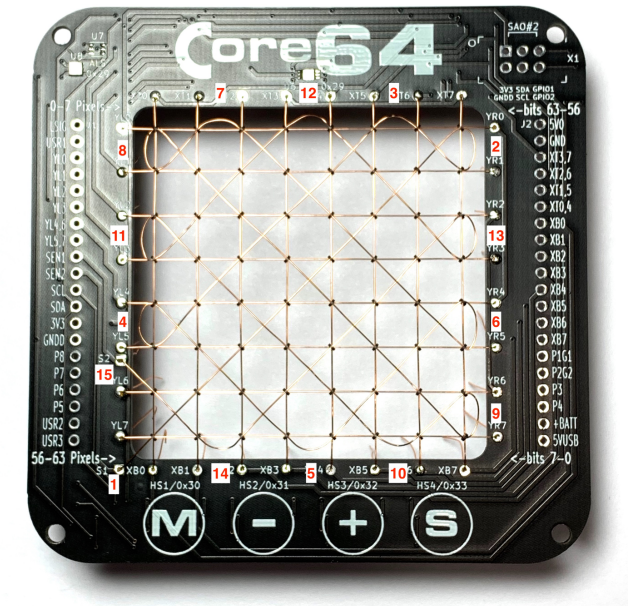
Be careful handling this wire, especially the long floppy part that is outside of the plane while you are focused on weaving the tip. You don't want to let it snag on something and get a kink in it.

The next step is to take the free end that is extended out of the upper right corner and follow the path taking shape here:

It is helpful to use a tweezers, and be slow and careful. When you turn the corners, it helps to have a small blunt tip object to arc the wire around and get it to form the right shape. You want to avoid kinking the wire or putting too much strain on the X-Y weave that is already in place. Here is an example using the outside edges of the tweezers (with it's flat faces squeezed together against each other) in order to guide the wire in a gentle curve while I am gently pulling on the wire from the upper left (out of view):



The sequence for the sense wire 1 to 15 as shown here:



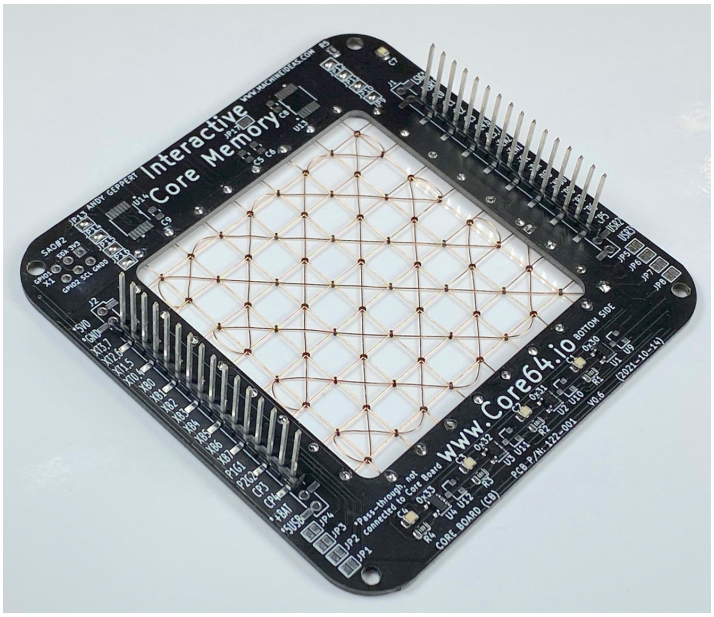
Now solder the sense wire on the back side at the S1 and S2 pads. Verify good continuity with a multimeter. You can put the probes on the SEN1 and SEN2 pads in the middle of the left side to ensure the connections are good. Another video of these last steps: https://youtu.be/SAAkIWg5GDQ
During the sense wire weaving process, you might have bumped the X/Y wires out of place. You can gently nudge them back. If needed, you can go around the perimeter of the board and reflow and retention the wires.

STEP 8: Trim off the excess wire

When you are happy with the wire alignment and have double-checked the continuity of all the wire solder joints, you can finally trim all of the excess wire off the back side. A few more details in the video: https://youtu.be/g-dSgPB2wDE
Admire your work!

STEP 9: Install the headers

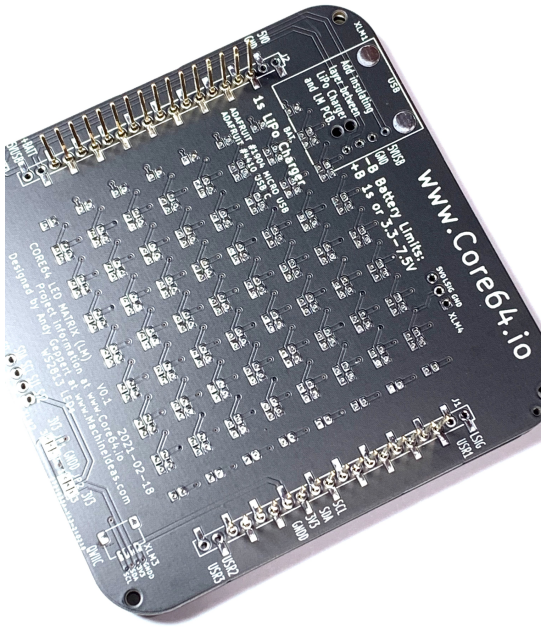
The left and right edges of the core board have 20 solder pads, but you will only be soldering headers into the middle 16 pads of each side. The top and bottom pairs, on both the left and right, are not used in the core board. Cut the 36-pin long header into two 16 pin headers, leaving 4 extra pins to set aside for optional use later. This is how the Core Board will look with the long pins of the headers on the bottom side of the board.



Using the LED Matrix as a fixture (do not solder to it in this step), sandwich the headers in place against the Core Board. In this photo, the top of the Core Board is facing right against the spool of solder, and the LED Matrix is on the left, with the LEDS facing right, under the Core Board.

Cut the excess header pins off that are sticking up above the top surface of the Core Board. Proceed to solder the headers in place. Keep them parallel to each other and perpendicular to the Core Board. If you solder each pin once, and let the solder flow in and fill just barely to the top of the pad, you can come back around a second time and touch a small bit of solder to the top of each pad and get a rounded top on the solder joint. This will prevent scratches on the screen protector.

Here are the headers poking out the backside of the LED Matrix board. The Core Board is underneath, face down, and not visible:



After all this soldering, clean off any flux with isopropyl alcohol. Be careful around the wire weave. Congratulations! Core Board assembly is complete. Time for screen protector.

10. SCREEN PROTECTOR INSTALLATION

You can install the screen protector now or leave it off until you are sure the system is working.

> ⚠ Be careful working with the Core Board so you don't damage the weaving. The Screen Protector will prevent damage from the stylus.

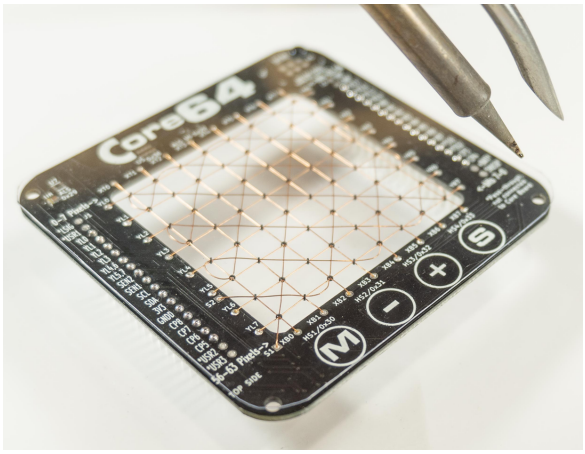
The included screen protector (two or three thin transparency sheets in the Core Board bag) may be a little too big. That's OK because you need to trim it to fit with a sharp hobby knife after it is installed.

To install the screen protector, align it on the top surface of Core Board, and make the edges flush with two adjacent edges on the Core Board. There is no need to cut an opening for the Ambient Light Sensor (ALS).

Step 1: Melt One Hole

Heat up a conical solder pencil and clean the solder off the tip with solder wick. This prevents solder deposits on the plastic.

Hold the screen protector in position tightly (or use tape or binder clips) and touch the solder pencil tip QUICKLY in-and-out through the screen protector into one of the corner holes of the Core Board. Try to aim the tip slightly outward as you pierce the screen protector, as shown here:

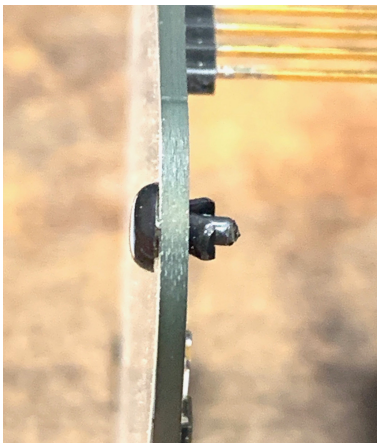


Using the technique of "pointing outward" helps to keep the hole from being created too large on the outer edge. For the best fit, insert the rivet after each hole is made to lock the corner in position.

Step 2: Insert One Rivet

Step 3: Melt Second Opposite Corner Hole, Insert Second Rivet

Keep the screen protector stretched flat across to the opposite corner and make another quick hole with the solder tip. Insert the rivet.



Step 4: Melt Third Corner Hole, Insert Third Rivet

Repeat step 3.

Step 5: Melt Fourth Corner Hole, Insert Fourth Rivet

Repeat step 3.

Step 6: Trim Screen Protector Outline

Once the screen protector is securely installed, you can place the Core Board face down on a cutting mat and trim the excess off the other two edges, and round the corners.

Step 7: Stack the boards

On the bottom is the Logic Board. Next up is the LED Matrix, and on top of that is the Core Matrix whose pins slide through the LED Matrix to connect to the Logic Board. I do not recommend soldering the Core Board header pins to the LED Matrix board. Except for SCL/SDA/3V3/GNDD if you intend the make use of the QWIIC port on the backside of the LED Matrix board.

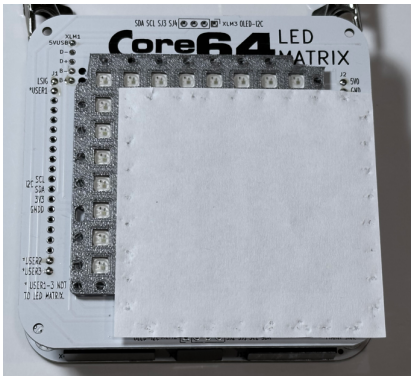
Optionally, you can place diffuser sheet layers between the LED Matrix and the Core Board. They can be held in by soldering in single pin headers in the LED Matrix board J3/4/5/6 positions. Those pins are exclusively there to provide a mechanical mounting point for diffusers. They have no electrical connection.

That's it for the Screen Protector Installation.

11. DIFFUSER LAYER INSTALLATION

Core64c V0.4 - Separator and Diffuser Included

This kit includes a LED separator grid and diffuser sheet. The diffuser sheet doubles as the welcome sheet - it's just a paper square outlined to cover the 3D-printed separator grid. These two components are simply stacked on the LED Matrix and held in place as a sandwich when with Core Array is installed.



Core64 V0.6 Separator and Diffuser Included

A diffuser grid is included and is stacked on top of the LED Matrix. Cut the diffuser from the envelope or a sheet of paper to match the size of the separator.

Core64 V0.4 and V0.5 - NOT INCLUDED

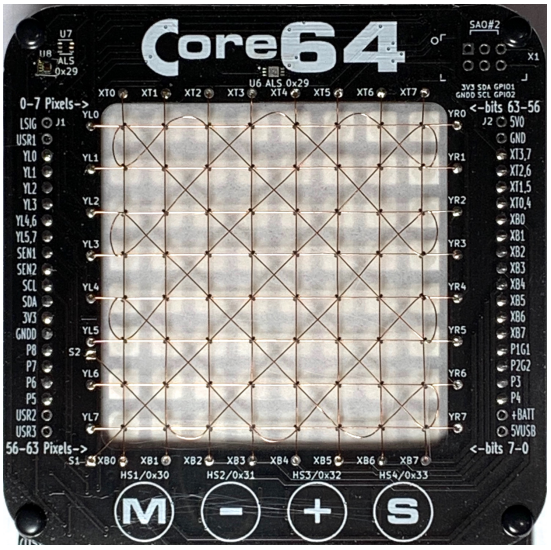
This step is optional, and you can substitute other diffusion layers and experiment with different materials. The benefit of the diffuser layer is two-fold. When the LEDs are off, the core weaving stands out much better against the white background without the distraction of the LEDs. The diffuser can also soften the LED brightness, and helps mix the Red/Green/Blue elements better.

In the kit are two thin diffuser sheets. They are meant to be installed between the Core Board and the LED Matrix board. An alternative to the following instructions is to cut the diffuser sheet to a suitable size and tape it to the bottom (back) side of the Core Board.

Cut four of the left-over single pin headers to install in J3, 4, 5, 6 positions on the LED Matrix, just above and below the LEDs. The top end of each pin needs to be trimmed off flush with the top of the plastic header spacer. Like this:

Solder in the pins from the bottom side of the LED Matrix. Then trim off the excess pin protruding beyond the solder joint. Now trim the diffuser sheet to fit in between the pins you just installed to retain the sheet from the top and the bottom. The left and right retention is provided when the Core Board is installed.

When all of the boards are assembled and stacked, the diffuser sheet is trapped in place.

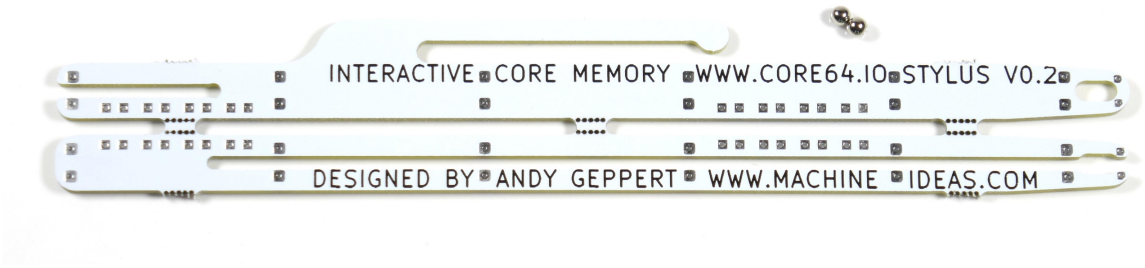


You can experiment with more than one layer, or different materials. If you'd like to make a grid or experiment with structure around the LEDs, each LED is 5x5mm and the spacing is 6.75mm center to center. [Here is a sample part to start with at OnShape](#).

Once the Onshape page loads, right-click in the lower left corner, and the part name, to export the file as an STL.

12. Stylus Assembly

The stylus assembly is easy - be careful separating the two boards. It is easy to accidentally break the stylus clip arm or the long thin strips that make up one half of the stylus. Don't let the little magnets get away from you either.



> ⚠ Be very careful separating the two stylus components. They are very thin and fragile. When breaking the pieces apart, use flat face pliers or similar on each side to ensure the break happens across the mouse bite holes.

Separate the two halves of the stylus. Slide the two stylus halves into each other held at 90° to each other. Place the magnets into the small opening at the tip. In some versions of the stylus (V0.3 RED) you may have to gently tap the magnets into the opening because the fit is tight.

Align the two halves of the stylus (hold with tape) and solder them together at the square pads which are adjacent to each other. You can skip every other set, and solder as much as you want, or a bare minimum to keep the assembly rigid and prevent the magnets from escaping.

File or sand away the sharp edges. Take extra care to sand/polish the tip of the stylus so there are no sharp edges that will scratch up the screen protector.

The final stylus assembly looks like this:

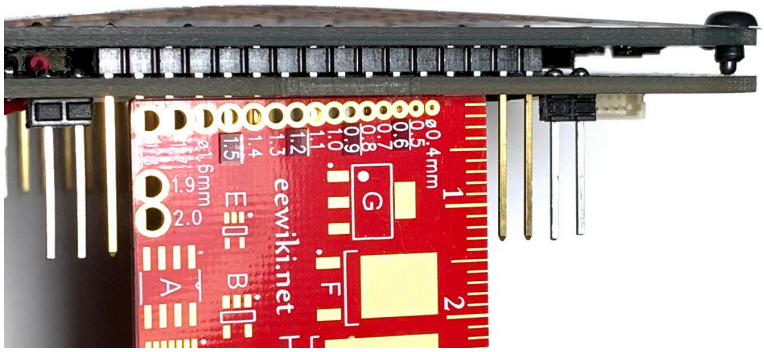
If you think the magnet strength is too weak you can carefully sand away more material at the tip so the magnet will be closer to the cores.

Thus completes the magnetic stylus.

13. Final Assembly

Step 1: Trim the LED Matrix header pins

Stack the Core Board into the LED Matrix.
If the 8 pins extending from the LED Matrix board are longer than the Core Board pins, trim the LED Matrix pins to match the Core Board while they are stacked.

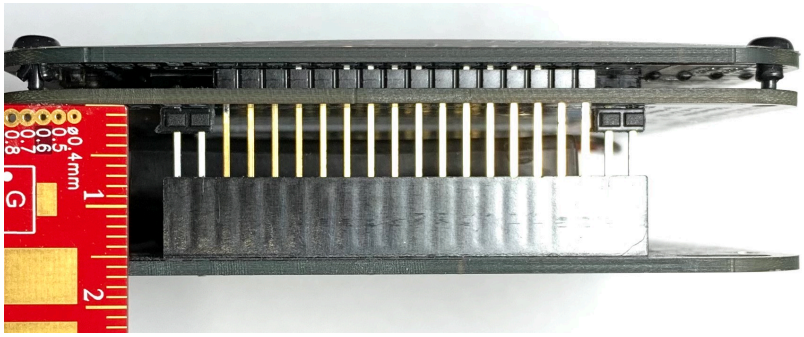


Step 2: Install Batteries

Insert the four "AAA" batteries into the battery holder.

Step 3: Stack the Boards

Core Board is on top.
Diffuser grid and sheet are on the LED Matrix.
LED Matrix is in the middle.
Logic Board is on the bottom.



In the early kits, you can place a diffuser sheet layer between the LED Matrix and the Core Board which can be held in by soldering in single pin headers in the LED Matrix board at J3/4/5/6 positions. Those pins are exclusively there to provide a mechanical mounting point for diffuser sheet. They have no electrical connection.

I do not recommend soldering the Core Board header pins to the LED Matrix board. Except for, optionally, SCL/SDA/3V3/GNDD if you intend the make use of the QWIIC port on the backside of the LED Matrix board. Those signals are also routed to the top and bottom edge of the LED Matrix as 0.1" 4-pin header rows. The same QWIIC port and I2C pins are all available on the Logic Board too. And the I2C pins are available on the Core Array.

Congratulations! It's all together!

You can slide the power switch on the Logic Board to the ON position and you should see text scrolling across the LED display. If so, move on to the Core 64 User Guide to learn all about the built-in functionality.

Now is also a good time to install the latest firmware. See the Core64 Firmware Update Guide.

The Core 64 User Guide also contains troubleshooting guidance if the kit isn't working correctly.

14. Troubleshooting

Please refer to the **Core64 Troubleshooting Guide**.

See also: https://www.Core64.io/Support

You may also find support here: https://discord.gg/nPcTNNfMmd