VIC-II² Installation Instructions

for 250407 motherboards (VIC-II² v1.0.407) and 250425/250466 motherboards (VIC-II² v1.0.425)

Updated December 11, 2022

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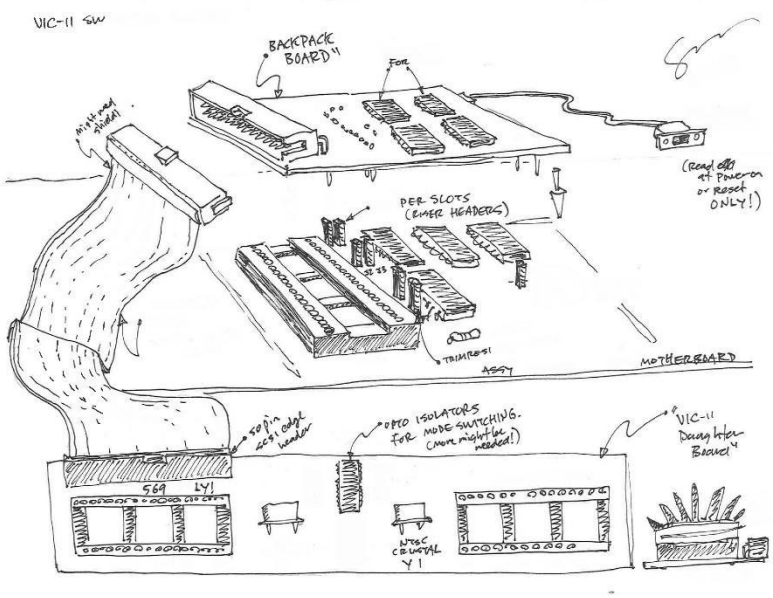
Background

In late Summer of 2018, Christian Simpson aka Perifractic and I began collaboration on a project that would become the VIC-II² Card (pronounced VIC-TWO-SQUARED). Our shared love of Commodore 64 and retro technology made it an easy partnering. Christian had already performed a conversion of an NTSC version of the C64 to PAL as part of his Retro Recipes YouTube channel, but he was looking for a method to more easily switch between the two modes. Why would you want to do that? In some cases, software that was written to run on PAL may not work properly on NTSC, and vice-versa. The manual modification requires swapping out the VIC-II chip (MOS 6567 for PAL and MOS 6569 for NTSC), the timing crystal (17.734475 MHz for PAL and 14.31818 MHz for NTSC), and then changing jumper settings on the motherboard so that the C64 knows in which mode it should be running. So, Christian posed the question, "What if we could switch all of those modifications at once, with both options installed?" We began discussing ideas and sketching ideas on how to make this happen, given the technical and physical constraints of the types of C64 machines people would be installing our solution into. I came up with this early sketch as a starting point…



It's fanciful to look at in retrospect, particularly the naïve suggestion that the signals of the VIC-II chips could survive routing through a flat or ribbon cable of that length (what were we thinking?). I built a dozen versions of this board before we settled on the final one, meandering between a logical digital switching solution, to a mechanical switch (literally a 10p2t push switch), to the final analog relay solution. We also went through both through-hole and SMD versions of many of the components, settling eventually on a solution that could be hand-soldered by most semi-technical enthusiasts.

The journey from that original sketch to a fully working 1.0 version took about eight months of part-time work. Christian was very patient with me as I tried (and failed) to get individual portions of the system to work. The solution is simple, but it's not perfect. We would prefer to have gotten the digital switching option to work rather than use analog relays, and that a mechanical toggle switch doesn't have to be

used, as that implies that either a hole be drilled in the case, or a “pig-tail” with the switch attached dangle out an already-exposed hole in the rear of the case. The solution also requires a bit more modification than most casual C64 users may want to undertake. While we’d love this to be a simple plug-n-play solution, it is not… RF shields must be desoldered and removed, components and jumpers must be desoldered with pins soldered in to replace them… this is not as simple as plugging in a cartridge.

But the VIC-II² card does offer something that many C64 lovers have wanted: an easily-switchable NTSC or PAL solution that uses hardware rather than software emulation. I’m sure that we’ll eventually solve the digital switching problem, possibly modifying solutions where the RESTORE key has been used to toggle ROM versions. For now, enjoy the fruits of our labor, and get ready for a fun and interesting install.

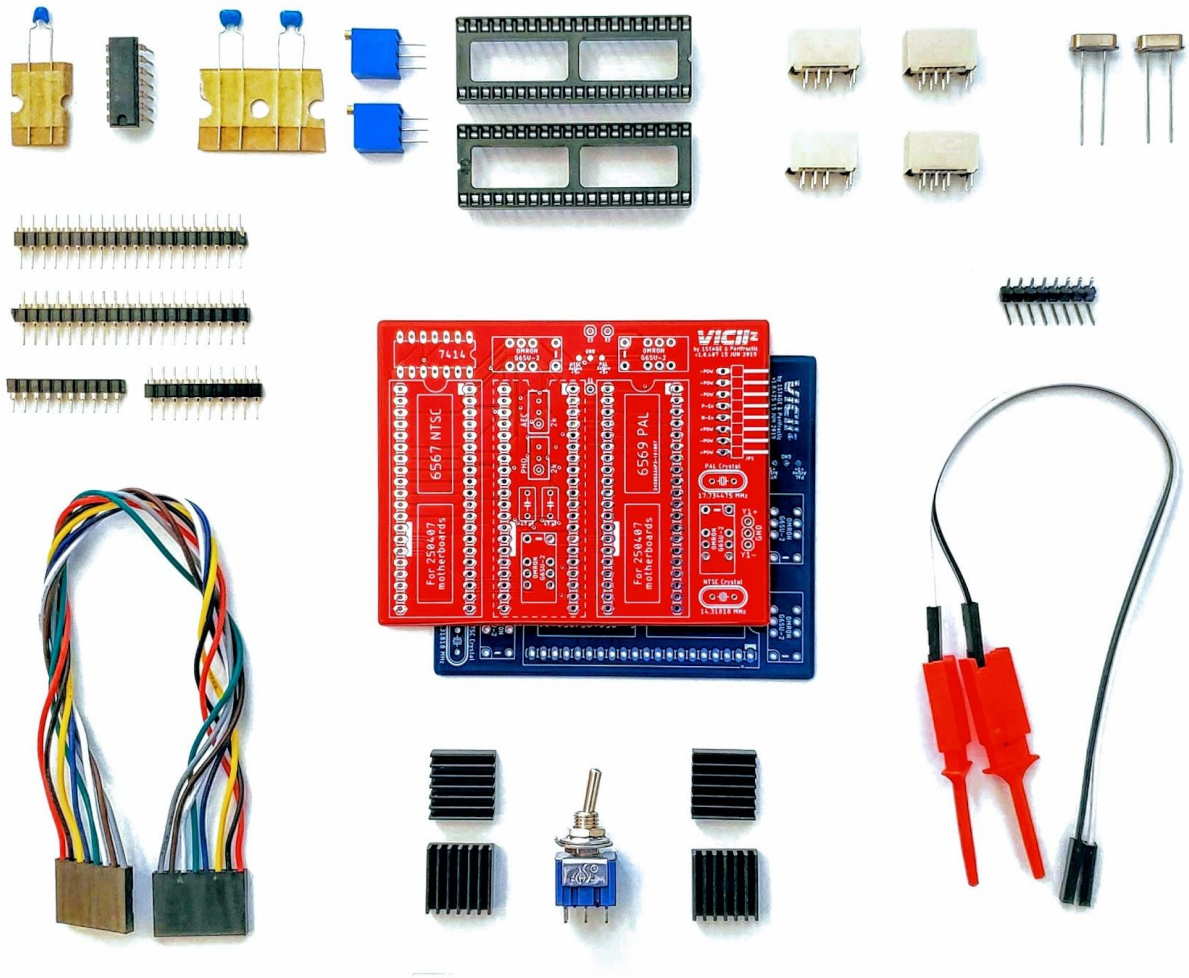
Sean Harrington, Technical Designer
October 11, 2019

Disclaimer

The modifications detailed in this document are for informational purposes only. These instructions offer a best-case scenario for completing these modifications. Readers undertake these modifications of their own free will, and the authors will not be responsible for damage caused by referencing these instructions (either correctly or incorrectly). Due to the wide variety of circumstances that the equipment to be modified may have endured, no warranty is implied, and no restitution for damaged or non-functioning equipment (or related loss) will be made.

What's in the Box

Although there may be variations, you should have ordered all of the following via the links at http://perifractic.com:



List (clockwise):

- 1 x 7 pF Capacitor *(optional troubleshooting step)*
- 1 x Lumafix Inverter Chip *(optional)*
- 2 x Lumafix 47 pF Capacitors *(optional)*
- 2 x Lumafix Trim Resistors *(optional)*
- 2 x DIP Sockets
- 4 x Relays
- 1 x 17.73 MHz Crystal *(PAL)*
- 1 x 14.32 MHz Crystal *(NTSC)*
- 1 x 8-Pin Right-Angle Header
- 2 x Minigrabbers *(joined)*
- 4 x Self-adhesive Heat Sinks
- 1 x DPDT Switch
- 1 x 8-Pin Dupont Cable
- 1 x Short Row of Female Machine Pins
- 1 x Short Row of Male Machine Pins
- 1 x Row of 40 Male Machine Pins *(may be pre-cut into 2 x Rows of 20)*
- 2 x PCBs

Prerequisites for Installation

Physical Requirements

The first thing to establish is whether you can make use of the VIC-II² card upgrade or not. The first things to consider are the physical requirements for installation. There are as many different configurations and uses of the C64 as there are users in the world, and it's important to set expectations before continuing.

- **Breadbin case** – Due to the added height of the motherboard after installation of the VIC-II² card, our solution currently only works in the traditional "bread bin" style case for the C64. If you have a C64c-style case, there is not enough room beneath the keyboard to accommodate the socketed VIC-II chips and their heat sinks.
- It does not support the SX-64 or C128.

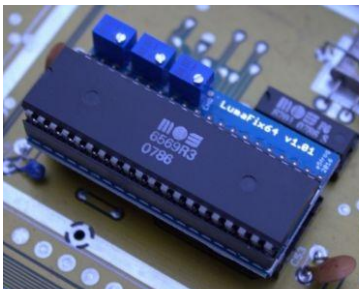
- **C64 250407 OR 250425 OR 250466 motherboards** – There are many versions of the C64 motherboard (aka Assembly Numbers), but the VIC-II² ONLY works with ASSY NO. 250407, 250425, or 250466. Unless you already know your motherboard version, you'll need to open your C64 case. The motherboard version is printed on the circuit board at the edge closest to the front of the computer. Also ARTWORK NO is not the same as ASSY NO.

(You'll use the RED VIC-II² board)

- (You'll use the BLUE VIC-II² board)

- **Second working VIC-II chip** – Your C64 will already have the VIC-II chip for your version of the computer (usually NTSC for North American and PAL for Europe), but you need the second VIC-II for the other format. These can be purchased on eBay or through C64 forums and swap meets. The PAL chip is a MOS 6569R#, and the NTSC chip is a MOS 6567R#. Usually any R# version is fine.

- **Lumafix** – Some enthusiasts have previously installed a Lumafix solution in the C64 which must be removed before installation. The Lumafix solution is a small circuit board that plugs into the VIC-II socket and allows users to adjust the amount of vertical banding on some monitors. The good news is that the VIC-II² board has the Lumafix circuitry built in, but it can be excluded if desired.



- **VIC-II heat sinks** – Adding our VIC-II² card requires the removal of the metal box (aka RF cage) around the VIC-II chip, but this box also serves as a means of cooling the VIC-II chip (which can get very warm). Since the metal box can't be used after the modification, a means of cooling down the two VIC-II chips must be addressed. Typically, self-adhesive aluminum heat sinks are recommended, but your VIC-II may already have a custom heat sink. The VIC-II² card raises the VIC-II chips about ½" (13mm) off the motherboard, so a custom heat sink on your existing VIC-II chip may interfere with the bottom of the keyboard when everything is installed back into the C64 case.

- **Case modifications** – The VIC-II² card circuitry is controlled via a DPDT (double pole, double throw) toggle switch attached to the VIC-II² board via an 8-pin cable. This cable is long enough to reach either the back or the right side of the C64 case, but there is no dedicated "hole" in which the switch can be mounted. Users will have to decide for themselves whether a case modification is desired, or the switch can hang out an existing hole/port in the case. Our preference is not to make holes in these vintage machines, but if you own the machine, it's up to you how to preserve it.

- **Compatible Monitor/TV** – Since you're modulating the composite output from your C64 at two different frequencies after the VIC-II² is installed, you MUST have a monitor/TV that can display the new format on it, whether that be NTSC or PAL. Many modern televisions already have multi-frequency compatibility built-into them, but you'll need to check first to verify if yours supports both NTSC & PAL. Using a stock Commodore monitor will usually NOT produce acceptable results for the new frequency you want to use. An alternate solution is to use an upscaling device that converts NTSC or PAL into HDMI, such as the XRGB Mini. Do not assume your TV will automatically work, as it's usually the main problem in implementing this update.

Functional Requirements

In addition to the physical requirements of performing this modification, there are functional and technical skill requirements that you (or someone you trust) will need to meet before attempting this upgrade. We want to be very open and honest about undertaking this modification…

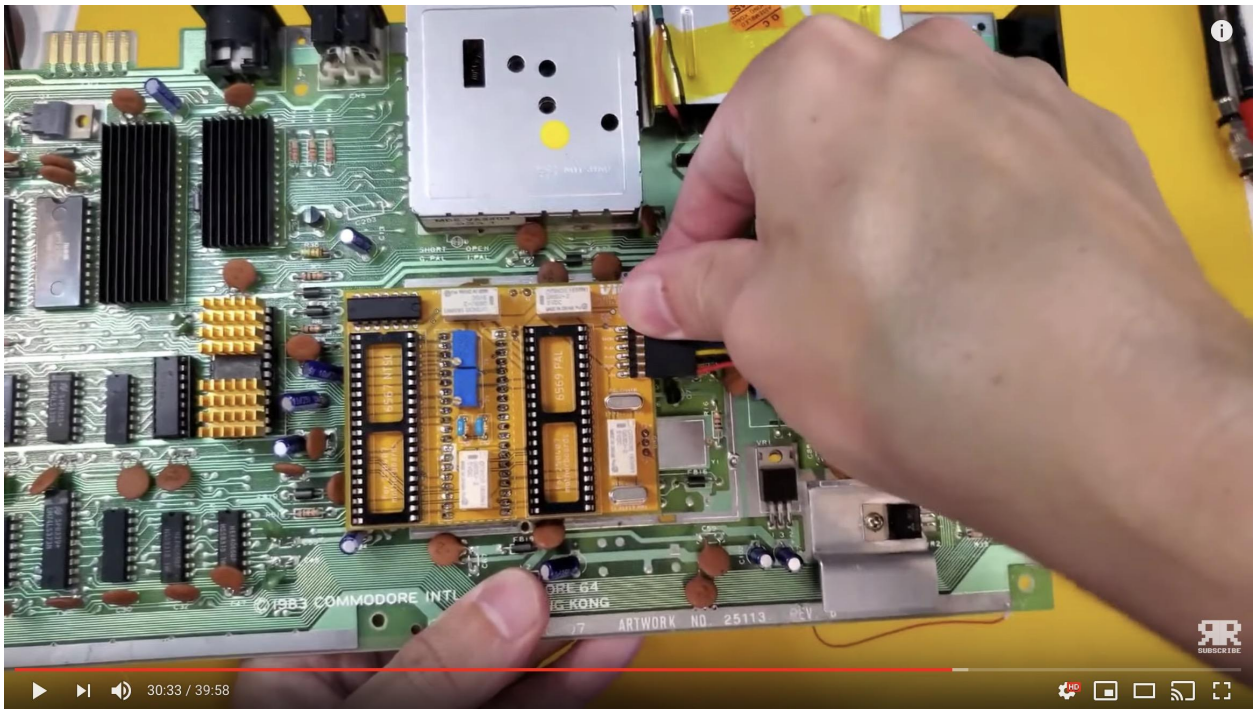
This is not a casual plug-n-play upgrade to the C64!

You will be making modifications to your original C64 motherboard that add NEW functionality. The work to be performed is reversible, but you will be replacing some stock components with new ones. If this bothers you, this is probably NOT an upgrade you should perform.

Final Encouragement

So, enough of the scare tactics. If the benefits outweigh the risks to you, we are with you on this journey. This isn't the first modification to a stock system that has given enthusiasts pause. You can do this if you're committed. In the next sections, we'll go over the installation procedure in detail.

Installation video guide



Feel free to follow along with Perifractic's video installation guide (starts at 15:42):

bit.ly/viciivideo

Or watch the full project development video, including the guide:

https://youtu.be/XONgqVT8pd0

Detailed Instructions

Planning

C64 Forums

We can't stress enough how important it is to have a peer group of fellow C64 owners. Everything new I've learned about the C64 came from my C64 friends, both in the 1980s when I owned my original computer, and 40 years later now that I own several replacement C64s. The main difference today is that I have earned 40 years of confidence in electrical engineering which I can contribute to the community.

I can personally recommend the Facebook Commodore 64/128 group as a supportive and vibrant group of C64 enthusiasts. The Lemon64 Forum (www.lemon64.com/forum) is also a great resource, as are the C64 threads on the Amibay Forum (www.amibay.com/forum). Note that there are participants with VERY strong opinions on these forums, so go in with the goal of reading and listening first, and you'll be fine.

C64 Motherboard Version

Unless you already know, the only way to confidently determine the version of motherboard your C64 has is to open the case and look. Even if the serial number on the bottom of your computer says one thing, there's always a chance that a different configuration exists on the inside. Even if your case is that of a C64c, you stand a good chance of having an older motherboard inside of it. While you won't be able to use the 64c case, you CAN use the motherboard in a breadbin case.

To open the case, first unplug and remove ALL peripherals and cables, then turn the computer upside down and remove the screws on the bottom (typically six of them). Next, holding the top and bottom halves of the computer together, carefully flip the unit over so the keyboard is facing up again. Carefully lift the back of the top half of the case toward you, using the front edge as a hinge. There are a few plastic tabs there that should release as you tilt. Carefully unplug the keyboard cable from the motherboard and set the top of the case aside.

In MOST models of the C64, you should now be able to see the bottom edge of the motherboard below where the SPACE bar normally sits. You want to see the words "ASSY NO. 250407", "ASSY NO. 250425", or "ASSY NO. 250466". Also, you will have to select the appropriate version of the VIC-II² card: the RED-colored v1.0.407 for 250407 boards, or the BLUE-colored v1.0.425 for 250425/250466 boards. Two boards are due to the different layout of the VIC-II chip and the positioning of the crystal and jumpers on these versions of the motherboard. Again, ARTWORK NO is not the ASSY NO.

Installation Work

Based on everything that has been mentioned so far, now is a good time to determine whether you are up to the task of performing the installation work yourself or not. If you're not, you will need to establish an agreement with someone to do the work for you. Note that simply buying a "pre-assembled" version of the VIC-II² card and switch cable will not save you from having to perform the motherboard modifications. In fact, assembling the VIC-II² card and cable requires ONLY soldering work, not desoldering. Since building these components from parts is mostly through-hole soldering (no SMD/surface mount work required), it is fairly easy. But modifying the motherboard DOES require the added skill of desoldering about six pins/pads.

Case Modification

The VIC-II² switch can usually be dangled unobtrusively out the back of the C64 through the cartridge port or the RF channel switch hole. This requires no modification of the plastic case. If you want to move the switch to another location, additional wire will have to be added to increase the length of the cable.

We do not recommend or favor modifying classic C64 cases. However, for those who demand a more permanent solution, a hole can be made in the back of the C64 case, and the toggle switch can be more securely mounted with the included retention nut. You'll need to decide which approach is your preferred one and adapt your solution to match (i.e. ordering a longer cable with female DuPont connector as your source cable).

Other Components you will need

You may also need the following:

- Solder – Enough to solder about 200 pads, probably 24" of thin lead-free solder
- Heat Shrink Tubing – Enough to protect 8 @ 18-gauge wires and solder lugs on the bottom of the DPDT toggle switch (probably 8" of 1/8" shrink tube and 2" of 5/8" shrink tube to bundle the switch end of the cable)
- Zip ties – To secure the cable inside the C64 along its path to the outside of the case
- Solder wick – If you're not using a desolderer, about 6" of copper solder wick will aid removing the motherboard components
- Flux paste – Helps desoldering by "wetting" the solder joint
- PCB cleaner – Remove flux and spatter from the motherboard and VIC-II² card after soldering, either IPA (isopropyl alcohol) or commercial motherboard cleaner works fine

Second VIC-II Chip

You will need to first determine the version of the VIC-II chip you have and then acquire the complementary version. The best way to determine this is to open your computer up, pop the top off the RF cage that surrounds the VIC-II, and read the chip number. If you have an NTSC MOS 6567, you need a PAL MOS 6569, and vice-versa. We usually purchase these chips from retroleum.co.uk, or eBay - making sure that the seller is well-rated and guarantees that the chip is in working condition. The bad news is these chips are no longer manufactured, and there are currently no reproduction options available. The good news is that millions of them were manufactured, so you should have an accessible supply to choose from. ***If you have a VIC-II chip that begins with 85xx, it will not work with the VIC-II² card.***

Multi-Mode Monitor

Depending on your current monitor set-up for your C64, you might have to find a new solution. For the most part, composite CRT monitors like the Commodore 1702 Video Monitor only work (well) in one mode: either NTSC or PAL. The other mode will give a black & white image, even with the VIC-II² installed. Similarly, if you rely on the RF modulator (switches between Ch 3-4 on standard televisions), you will likely have to find a new monitor solution.

The good news is that a few modern LCD televisions have circuitry that will automatically switch between either NTSC or PAL mode when plugged into the composite input port of the TV. When looking for a solution, search the specifications of the television you're considering for compatibility with both PAL and NTSC formats. Alternately you can use an up-scaler, a conversion box that takes legacy video signals and converts them to modern formats. These are available in a wide range of prices and levels of

sophistication. Less expensive models have significant lag-time (up to 500 milliseconds!) between when the signal is generated and when it displays on the screen. This can be HIGHLY problematic when playing games, so consider this option cautiously. Better up-scalers use faster processing chips to reduce the lag-time to only a few dozen milliseconds, but they can be VERY expensive. The device you're looking for should be either RCA to HDMI or S-Video to HDMI (i.e. AV2HDMI boxes on Amazon), depending on what your current monitor uses. Do NOT purchase an HDMI to RCA or HDMI to S-Video converter, as these are actually down-scaler devices. They have similar pricing and model names (i.e. HDMI2AV), so be careful.

Note that you will still need a C64 monitor cable that has composite or S-Video output. While the RF cable and switch box can sometimes be used, most modern TVs have abandoned the "antenna" input and tuner required to make this work.

If you have a black & white picture after considering the above, please see the Troubleshooting & Support section at the end of this guide.

Installation Tools

Unless you are opting to have someone else build and install your VIC-II² card and switch cable, you will need many of the following tools to complete the install yourself:

- Soldering iron – you should have a decent soldering iron that can generate about 15 watts of power, fitted with a new, fine tip that has been properly tinned and prepped; for best results, an iron from a reputable manufacturer (Weller, Hakko, etc.) with an adjustable temperature setting up to at least 750° F (370° C) is recommended, along with a "solder station" that can hold the soldering iron and wipe the tip clean of excess solder
- Desoldering iron – you should have one of the following solutions for removing solder: a good-quality desoldering iron with vacuum pump (manual or automatic is fine); a manual solder vacuum tool; solder braid/wick + flux that can be heated to soak up old solder
- Screwdriver(s) – a standard Phillips-head screwdriver is needed to remove the case screws as well as the screws holding the C64 motherboard in place; a smaller set of precision flat blade and Phillips-head screwdrivers can also be useful when removing smaller screws or changing the settings of the trim resistors in the Lumafix circuit; the iFixIt tool kit is a popular choice for this
- Anti-static mat and grounding strap – having a workspace that won't build up static electricity that can damage your electronics is important, so we recommend both an anti-static work mat and a grounded wrist strap that you can use to ensure your components stay safe
- Chip puller – a tool designed to safely remove large IC chips like the VIC-II is strongly recommended; alternately a short, flat-bladed screwdriver can be used to carefully pry the chips up
- Multimeter – A digital multimeter is essential when checking your work; get one with a sound/tone notification for CONTINUITY checking
- Helping hands – having a set of articulated arms and clips that can hold parts of the VIC-II² board for you while you solder can decrease your frustration
- Lighter or heat gun – when using shrink tubing, if you have a controlled heat source that can be used to shrink the tube, your installation will go quicker
- Project board – if you have any electronics kits that have pin-hole project boards, these can be used to align the two sets of header pins needed for the VIC-II pins on the VIC-II² board while soldering them in place

- Flush-cut trimmers – when pruning the remaining wires from your through-hole components, or in cutting the break-away header pins to the proper length, a set of flush-cut trimmers are very useful
- Small needle-nose pliers – these are often sold in a kit with the flush-cut trimmers (above), and these small pliers are great for positioning items while soldering, and for removing the extra pins in the unused header
- Picks or probes – while this can be accomplished with an X-Acto as well, having a dedicated "dental pick" to move parts around carefully can be useful
- Fume extraction fan – soldering can cause hazardous fumes, so having a small fan in your workspace directed away from the area can pull this smoke away from you; some have filters

All aboard! Train is leaving the station...

Disassembly

Since the disassembly phase begins the major "hands on" part of the installation, you should have already completed all Planning and Procurement tasks. Again, if you're following this section in detail, it assumes that you will be performing the modification and installation yourself. If you are not performing these tasks, it will give you an understanding (and appreciation) of everything your installer is doing on your behalf.

Unplug Everything

The first thing is to unplug everything from the C64: power cables, monitor cables, joysticks, modems, cartridges, tape or disk drives, or anything extra your set-up has. This cannot be stated strongly enough: there is no good reason to leave anything attached to your C64 once disassembly and installation begins.

Remove Motherboard from Case

First, you will set up a clean, static-free environment in which you can begin the disassembly. An anti-static mat and grounding wrist strap are recommended, and for the first step of opening the C64 case, a shop towel can be first laid down to prevent damage to the keyboard. Placing the C64 face down with the bottom up, remove the three screws on the back of the case, setting them carefully aside to prevent loss.

Grasping both sides of the case, careful flip the C64 back over so the keyboard is facing up. Carefully lifting the top front edge of the case, tilt the top of the case backward. The keyboard will come with the top, so it will be heavier than you expect. The keyboard has a cable on the left side connecting to the motherboard, but before removing it, you must ensure that the three plastic tabs on the back edge of the case are separated so they don't break. There is also a cable connecting the POWER light (LED) to the motherboard). Leave this cable alone for now.

From here, you can carefully set the top back down on the bottom (slightly askew keeps the tabs from clicking back in place), making room to the left of the computer to set the top/keyboard half down. Now you can carefully pull the keyboard cable out of the motherboard. You might need to wiggle it a little to get it loose. When it's free, remove the LED cable from the motherboard, but leave it attached to the top case. You can take this opportunity to briefly clean the top half of the case and the keyboard before setting it aside for reassembly. Our upgrades to not involve the keyboard or top of the case, so they can be left alone.

Now is also a GREAT time to double-check that you have a motherboard printed with "ASSY NO.250407", "ASSY NO.250425", or "ASSY NO.250466" at the front edge. If not, go back to the PROCUREMENT step to assess your options. ARTWORK NO is not the same as ASSY NO.

In the bottom half of the case, find the seven screws that hold the motherboard in place. These are usually around the edges of the motherboard: four in each corner, one on the middle front edge, one on the middle back edge (between the monitor and drive ports), and one about 4" to the left of that one, between the user port and the cassette port. These screws are different from those used on the bottom of the case (they are shorter), so set them aside separately from the case screws from earlier. Don't remove the two screws on the right side of the board that hold in the power and joystick port cover. Once the motherboard screws are removed, it can be carefully lifted out of the case, taking caution to maneuver the ports and connectors out of the case without damaging them. Set the motherboard aside

in a safe place for the next step. As with the case top and keyboard, feel free to take the time to clean any dust or debris out of the bottom of the case with a soft towel and mild detergent.

Desolder Bottom RF Shield

Assuming your bottom RF shield has not already been removed, this will be the next step in disassembly. Clear your work surface and make sure the top of the motherboard is facing up with the rear ports furthest away from you. Prepare your desoldering tools (iron, braid, flux, vacuum, etc.) and allow the iron to heat up to at least 600° F.

There are several different configurations and types of RF shields that were used on the C64. If your RF shield is ONLY made of foil-coated paper, you won't have to do any desoldering. Simply remove the shielding from it's "hooks" (sometimes adhesive tape).

If you have a steel or copper metal RF shield on the bottom (most common), you will have to either melt and then wick or vacuum the molten solder that holds the RF shield in place, or just cut the tabs and remove the shield that way. There are anywhere from seven to ten metal tabs around the top perimeter of the motherboard to which the metal RF shield is soldered. You will have to melt the solder, remove it (again, wick or vacuum), and then carefully lift the metal tabs and bend them away from the board. Even after the solder is removed, the tabs can still be stuck, so take your time and be patient. The good news is that these connection points on the motherboard are the large GROUND planes around the edges of the board, so your chances of doing any significant damage is marginal.

When all tabs on the RF shield have been desoldered, you should be able to remove the shield in a single piece. In the event you cannot remove it cleanly, you CAN snip/cut the tabs to remove the RF shield. The common consensus in the C64 community for the RF shield is that Commodore added it in an abundance of caution at the direction of the FCC to prevent noise interference. For that reason, we recommend NOT reinstalling the RF shield once installation of the VIC-II² card has been completed. If you prefer to keep your machine pristine, you'll need to finish cleanly desoldering the tabs until they come free. This will allow you to re-install this shield later yourself. We won't cover that here, as it's basically a reverse of this process: bend the tabs back around the motherboard and then solder them in place.

Desolder VIC-II RF Cage

As easy as the bottom RF shield may have been to remove the metal cage around the VIC-II circuitry will be a bit more challenging. Like the RF shield, we will not be re-installing the RF cage once our VIC-II² card is in place, so cutting the tabs (now on the bottom of the motherboard) are another last-resort option to removing a stubborn shield. Start by carefully popping the top cover off the VIC-II RF cage. It's the metal box on the top side of the motherboard, to the center-right of the board.

Now is a GREAT time to double-check the versions of VIC-II chip you have, both on the motherboard (it's the BIG chip inside the metal box whose lid you just removed) and the one which you ordered online. You should have both a MOS 6567 (NTSC) and a MOS 6569 (PAL), both 40-pin chips. You should NOT have a VIC-II with the prefix MOS 85xx. If you have any problems with your VIC-II, go back to the PROCUREMENT step to assess your options.

You'll be working MOSTLY on the back of the motherboard, so flip it over so the bottom is showing.

Note that the RF cage has eight tabs holding it in place: four small tabs that are soldered in place, and four larger tabs that (usually) aren't soldered in place. Carefully melting the solder on each small tab, wick or vacuum it up. Once most of the solder has been removed, use a pair of pliers to hold onto the metal RF cage from the top side of the motherboard. Begin carefully melting the remaining solder on each tab, gently pulling the metal box away from the motherboard from the other side. Continue to the next pin on the box, going around the perimeter until the box lifts cleanly off the motherboard. Once removed, you can finish cleaning up any remaining solder around the mounting points on the motherboard.

VIC-II Chip Removal

First, double check to ensure you're on a static-free workspace, and that you are properly grounded. Using either a chip puller or by carefully sliding a small flat-blade screwdriver beneath the chip, carefully remove the VIC-II from its socket.

Note that there are some versions of the VIC-II chip that are made from a ceramic material. They are a lighter grey and have brass/gold accents. These can be more brittle than the later plastic/resin versions of the VIC-II, so take great care when removing it, and DO NOT DROP IT ONTO A HARD SURFACE, AS IT CAN SHATTER!

Be careful to NOT bend any of the chip's pins. If you do, CAREFULLY bend them back to the original position once the chip is removed. IF YOU BREAK A PIN, YOU HAVE A LIMITED CHANCE THAT THIS VIC-II CHIP WILL WORK AGAIN! Set the VIC-II chip aside in a safe, static-free location, being careful to protect the pins.

Desolder Timing Crystal

Desoldering the timing crystal is fairly EASY: only two pins to remove (plus some grounding leads)! The crystal is a flat, shiny metal object about 2 inches to the right of the VIC-II socket, marked as Y1.

To make things easy, you're going to use your flush-cut trimmers to snip the two legs of the crystal close to the motherboard, as well as the grounding wires at the top and sides of the crystal. You don't need to keep this original crystal (you've already procured a replacement above), but if you would rather desolder it instead, you can do that. The mounting wires and the center pin hole on the crystal are both attached to the GROUND plane, so they will take a little more heat to remove.

If you opted to snip the leads first, finish up by removing the solder and the remaining wire from the three mounting holes on the motherboard. As with the socket pin holes, when properly desoldered they should show light through them and should all have the same size and round shape. You do not need to remove the solder that held on the mounting wires.

One desoldering task down. One to go!

Desolder PAL/NTSC Jumpers

On 250407 motherboards, the jumpers that tell the system which version of the VIC-II is installed are located just to the upper right of the VIC-II socket, marked E1, E2, and E3.

For 250425/250466 motherboards, the jumper is a single pair of leads that are either CONNECTED with a single wire (for PAL) or NOT CONNECTED for NTSC.

Again, for simplicity, you're going to snip the jumper wire that runs between either the NTSC or PAL pads, and then you're going to desolder the pin holes so that light can be seen through them. There is no need to keep the jumper wire.

Folding Taller Components

Now that we've desoldered everything, it's time to gently move some of the existing components on the C64 motherboard out of the way. Before you start, ensure that you're working on your anti-static mat and that you're grounded from static discharge. For the 250407 motherboard, perform these moves:

1. Gently fold/bend capacitor C101 (tan ceramic disk capacitor, above the VIC-II socket) to the left
2. Gently fold/bend capacitor C108 (black tube capacitor, upper right of VIC-II socket) to the right
3. Gently fold/bend capacitor C68 (tan ceramic disk capacitor, right of VIC-II socket) either up or down
4. Gently fold/bend capacitor C66 (tan ceramic disk capacitor, lower right of VIC-II socket) downward
5. Gently fold/bend capacitor C85 (blue or brown capacitor, 2" to right of VIC-II socket) to the left
6. Gently fold/bend capacitor C84 (tan ceramic disk capacitor, 2" to right of VIC-II socket) to the right
7. Gently fold/bend capacitor C60 (tan ceramic disk capacitor, above PAL/NTSC jumpers) upward
8. Gently fold/bend capacitor C82 (tan ceramic disk capacitor, right of PAL/NTSC jumpers) upward
9. Gently fold/bend capacitor C74 (tan ceramic disk capacitor, right of PAL/NTSC jumpers) upward
10. Gently fold/bend capacitor C56 (tan ceramic disk capacitor, right of PAL/NTSC jumpers) upward

For the 250425/250466 motherboard, perform these moves:

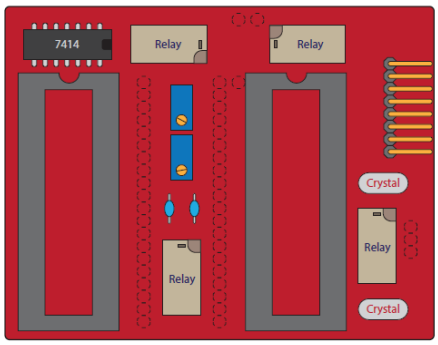
1. Gently fold/bend capacitor C101 (tan ceramic disk capacitor, left of the VIC-II socket) to the left
2. Gently fold/bend capacitor C15 (blue or brown capacitor, lower left of VIC-II socket) to the left
3. Gently fold/bend capacitor C58 (tan ceramic disk capacitor, right of the Y1 crystal) downward
4. Gently fold/bend capacitor C53 (tan ceramic disk capacitor, right of VIC-II socket) to the right

You are now done with the disassembly of the motherboard! No more desoldering! Yay!

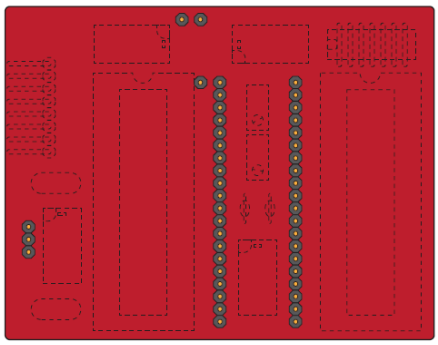
Installation

Now it's time to begin assembling the components that make up the VIC-II² card solution.

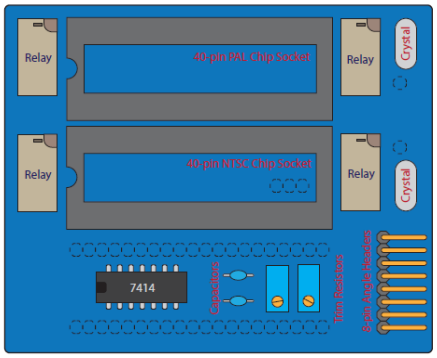
Front of VIC-II² 250407 Card



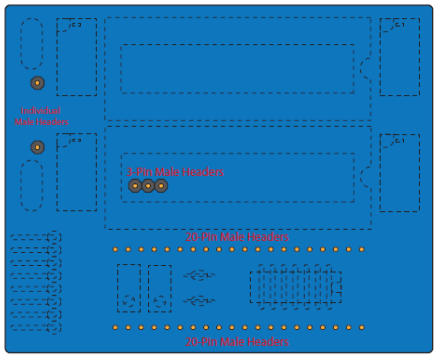
Back of VIC-II² 250407 Card



Front of VIC-II² 250425/250466 Card



Back of VIC-II² 250425/250466 Card



Build the VIC-II² Board

You're going to start with a clean and clear workspace. It should have an anti-static, heat-resistant surface to work on, and you should be grounded from static yourself using the wrist strap. Prepare the space by getting your soldering iron ready (again, 600 F), your safety goggles and fume management working (mask or fans), and ensure your solder, wick, flux, and other essentials are close by.

Next, set all the PCB components for the VIC-II² card nearby and let's get ready to build!

1. VIC-II Socket Pins
    a. Take the set of 40-pin male machine pin headers and break it in half so that there are two equal 20-pin pieces
    b. You will be inserting the SHORT side of the pins (with the metal "barrel") into the VIC-II² card from the BOTTOM (no printing on the BOTTOM), and soldering from the TOP side
    c. Using a project board, putty, or some other jig, hold the long side of the two rows of header pins so they are parallel to each other and perpendicular, and line up with the…
        i. MIDDLE row of holes on the RED (250407) VIC-II² card
        ii. BOTTOM row of holes on the BLUE (250425/250466) VIC-II² card
    d. Put the VIC-II² card onto the header pins (again, you're soldering from the TOP side), and solder ONLY the top two pins for each row, making sure you get a good "tent" of solder on the pins and pads

e. Next solder the bottom two pins for each row, again making sure you get a good "tent" of solder on the pins and pads
f. If the pins are still all lined up and are still perpendicular to the board, solder the remaining 36 pins, making sure you don't solder two adjacent pads/pins together (some pins have electrical connections within the circuit board, though)
g. Once the solder has cooled/cured, remove the board from whatever you're using to hold it down, and make sure the header pins are straight, perpendicular to the back of the card, and are firmly seated against the board with NO SPACE between the black plastic retainers and the VIC-II² card, reflowing the solder as needed on any pins that need adjusting
h. Using IPA (isopropyl alcohol) or a circuit board cleaner, remove all remaining flux and solder residue from the FRONT of the VIC-II² card

2. Crystal Header Pins
    a. Using the smaller set of 8-pin male machine pin headers, and break off a piece with THREE connected pins
    b. You will be inserting the SHORT side of the pins (with the metal "barrel" on it) into the VIC-II² card from the BOTTOM (no printing on the BOTTOM), and soldering from the TOP side
    c. Using a project board, putty, or some other jig, hold the 3-pin piece of header pins so they are perpendicular to the board, and line up with the three holes on the RIGHT side of the VIC-II² card
    d. Put the VIC-II² card onto the crystal header pins (again, you're soldering from the TOP side), and solder ONLY the top pin, making sure you get a good "tent" of solder on the pin and pad
    e. Next solder the BOTTOM pin, again making sure you get a good "tent" of solder on the pin and pad
    f. If the pins are still all lined up and are still perpendicular to the board, solder the MIDDLE pin, making sure you don't solder two adjacent pads/pins together; THIS IS A GROUND PIN, so it might take a little longer to heat up
    g. Once the solder has cooled/cured, remove the board from whatever you're using to hold it down, and make sure the header pins are straight, perpendicular to the back of the card, and are firmly seated against the board with NO SPACE between the black plastic retainers and the VIC-II² card, reflowing the solder as needed on any pins that need adjusting
3. PAL/NTSC Jumper Header Pins
    a. Using the remaining piece of 37-pin male machine pin headers, cut off THREE single pins
    b. You will be inserting the SHORT side of the pins (with the metal "barrel" on it) into the VIC-II² card from the BOTTOM (no printing on the BOTTOM), and soldering from the TOP side
    c. Since the pins are at an abnormal spacing, you won't be able to use a project board as a guide. Using putty, or gloved fingers, hold each of the NTSC/PAL pins in place while you solder them. RED board has THREE pins. BLUE board has TWO pins.
    d. Ensure that these pins are flush with the BACK of the VIC-II² board, and are as VERTICAL as possible, reflowing the solder as necessary. Crooked pins will make it VERY difficult to align with the motherboard holes.

4. VIC-II Sockets
    a. From the front of the board, insert the two 40-pin DIP sockets in their places on either side of the header pins you already installed, MAKING SURE THE TOP CUT-OUT NOTCH IS AT THE TOP OF EACH SOCKET (check the printing on the board)
    b. Holding the sockets in place, flip the VIC-II² card over and place it face down onto your workspace, keeping the sockets tightly pushed against the board from behind
    c. Solder the two top and two bottom pins for each socket, then lift the board to make sure that they are still firmly against the front/top of the board
    d. Continue soldering the remaining 36 pins on each socket, ensuring each pin/pad has a good "tent" to it, and that NO adjacent pins/pads are connected with solder (some have electrical connections within the circuit board, though)
    e. Perform a quick continuity check with a multimeter for each set of pins in the socket and headers, comparing one-to-one as you move down each side; NOTE, THERE ARE FOUR PINS THAT WILL NOT CONNECT! THEY ARE MARKED NEXT TO THE PADS… these are the four pins we switch as part of the VIC-II² functions, so this is normal
    f. ***For now, refrain from inserting the two VIC-II chips into their respective slots on the card***; we'll be fumbling around with the VIC-II² card for the next several tasks, and the VIC-II chips are safer if they stay in their foam pin protectors and anti-static bags
5. Cable Header Pins
    a. From the front of the board, insert the 8-pin, right-angle headers into the holes at the upper right side of the board; the black plastic separator on the header should be next to the board, allowing the pins to protrude from the back only slightly, and the longer header pins should point to the right edge of the card on the front
    b. Holding the header pins in place, flip the board over and solder one of the outside pins in place; ***be careful not to hold onto this pin while you're soldering as it will get VERY HOT!***
    c. Switch your hold on the header pins and solder the opposite outside pin in place, also taking care not to touch that pin when soldering
    d. Flip the board over and make sure the header is not crooked, and that the plastic spacer is very close to the board surface
    e. Flip the board to the back side again and solder the remaining six pins, ensuring that all pins have good "tenting" and that adjacent pins/pads are not connected with solder
6. NTSC & PAL Crystals
    a. From the front of the board, insert the PAL crystal (17.734475 MHz) into the holes at the bottom right of the VIC-II² board; the crystal is non-polarized, so it doesn't matter which leg goes into which hole; the printing on the card should confirm the same 17.734475 MHz frequency, although the crystal itself usually has 17.7C67 engraved on top
    b. Holding the crystal in place, flip the VIC-II² card over and set it on your work surface; the crystal will slide down a bit, but that's okay; you want a slight gap between the crystal and the VIC-II² card
    c. Solder each leg of the crystal on the back of the VIC-II² card, creating a good "tent" of solder attached to the base of the board

d. Flip the card over again and make sure the solder is holding the crystal in place; if the crystal slides back and forth, reinforce your solder joints on the back
e. Using the flush cutters, trim the legs of the crystal on the back of the board so that there is only about 1/16" (1 or 2 mm) remaining; trimming the legs too close the board can cause problems, so don't cut aggressively as there's plenty of clearance under the card when installed
f. Repeat the process with the NTSC crystal (14.31818 MHz), noting that the engraving on the top of this crystal will typically read 14.3C05

7. LumaFix
    a. ***The Lumafix circuitry is entirely optional***, and the VIC-II² card will work fine with or without it, but since you're taking the time to do the rest of this, the Lumafix components are easy to add and cost very little
    b. 7414 Logic Chip
        i. From the front of the board, insert the 14-pin 7414 logic chip into the holes at the top left of the VIC-II² board, ensuring that the notch of the chip is pointing to the RIGHT of the board, matching the printing on the card
        ii. While holding the chip in place, flip the VIC-II² card over
        iii. Solder the top left and bottom right pins of the logic chip in place from the bottom of the card
        iv. Continue soldering the remaining 12 pins on the chip, ensuring that each pin/pad has a good "tent" to it, and that NO adjacent pins/pads are connected with solder (some have electrical connections within the circuit board, though)
    c. Capacitors
        i. From the front of the card, insert either of the two 47pF capacitors in one of the two spaces for them in the middle of the VIC-II² card; these are non-polarized capacitors, so either leg can go into either hole, BUT the capacitors are installed VERTICALLY, so don't cross-connect the capacitors between the printing on the card… one capacitor per "box"
        ii. As with the crystals, flip the board over and set it on your workspace, allowing the capacitor to slide down a bit
        iii. Solder each leg of the capacitor on the back of the VIC-II² card, creating a good "tent" of solder attached to the base of the board
        iv. Flip the card over again and make sure the solder is holding the capacitor in place; if the capacitor slides back and forth, reinforce your solder joints on the back
        v. Using the flush cutters, trim the legs of the capacitor on the back of the board so that there is only about 1/16" (1 or 2 mm) remaining; trimming the legs too close the board can cause problems, so don't cut aggressively as there's plenty of clearance under the card when installed
        vi. Repeat the process for the second capacitor
    d. Trim resistors
        i. Take one of the two variable 2k resistors (also called trim resistors) and insert it in the upper middle part of the VIC-II² card so that the metal screw matches the placement shown on the board printing; there are three legs on each variable

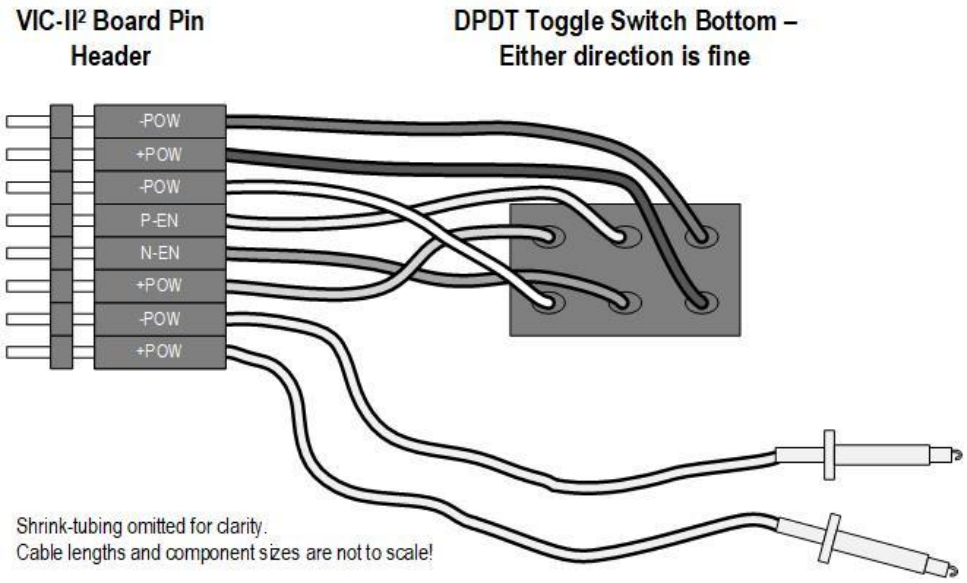
resistor, so make sure each leg slides smoothly through the card, otherwise you might have them in the wrong hole
   ii. Holding the resistor in place, flip the card over and solder one of the two outside legs of the resistor to the card, creating a typically good "tent" of solder
   iii. Flip the card back over and make sure there is little or no space beneath the card and the bottom of the variable resistor, and that the resistor is not crooked in either direction
   iv. Flip the card to the back again and solder the two remaining legs
   v. Using the flush cutters, trim the legs of the resistor on the back of the board so that there is only about 1/16" (1 or 2 mm) remaining; trimming the legs too close the board can cause problems, so don't cut aggressively as there's plenty of clearance under the card when installed
   vi. Repeat the process for the second resistor
   e. ***IMPORTANT: Later when you try the product for the first time, if you see vertical lines otherwise known as jail bars, please refer to the troubleshooting section at the end of this guide. Adjusting these resistors a great many turns is sometimes necessary. A position far counter-clockwise generally works well.***
8. Relays
   a. From the front of the VIC-II² card, insert one the four relays in place; there is only one way to insert them, and you can line up the "dot" in the corner with the "dot" on the printing
   b. Holding the relay in place, flip the VIC-II² card over and solder one of the corner legs in place, ensuring a good "tent" to hold it in place
   c. Solder the leg of the relay in the opposite corner
   d. Flip the card over and ensure that the relay is resting against the circuit board with little or no space beneath, and that the relay is not crooked
   e. Solder the remaining six legs of the relay, ensuring a good "tent" of solder on the leg and pad
   f. There is no need to trim the extra legs from the bottom of the relays
   g. Repeat the process for the remaining three relays
9. Finish & Clean Up
   a. Flip the board over and double-check all solder joints, ensuring they have good "tenting" and that adjacent pins/pads are NOT connected with solder
   b. Using either IPA (isopropyl alcohol) or a board cleaning solution, remove all flux and solder residue from the BACK side of the board
   c. ***As recommended earlier, refrain from inserting the two VIC-II chips into their respective slots on the VIC-II² card***; we'll be fumbling around with the VIC-II² card for the remainder of the assembly, and the VIC-II chips are safer if they stay in their foam pin protectors and anti-static bags

Build the VIC-II² Switch Cable

As with the card assembly, you're going to start with a clean and clear workspace. It should have an anti-static, heat-resistant surface to work on, and you should be grounded from static yourself using the wrist strap. Prepare the space by getting your soldering iron ready (again, 600 F), your safety goggles and

fume management working (mask or fans), and ensure your solder, flux, shrink tubing, and other essentials are close by.

Next, set all the components for the VIC-II² switch cable nearby and let's get ready to build!



1. Prep the 8-pin Cable
    a. The cable's plugs each have two sides: one that is smooth, and one that shows the pin connectors (metal tabs) through holes in the plastic. With the **smooth side** facing UP, and the female open sockets facing LEFT as shown above, locate the end of the cable that has the **RED** wire on the BOTTOM. (This is also the bottom wire as shown in the above diagram.)
    b. With the smooth side still facing UP, and the VIC-II² board also facing UP (logo on top), plug the selected end of the cable into the VIC-II²'s right-angle 8-pin header.
    c. Double-check your work, and that the smooth side is facing up. Make sure the red cable is as described above. If it is correct, you can now unplug the cable from the VIC-II² card header to modify it
    d. Using the tip of an XActo blade or fine metal pick, carefully lift the small black retaining tab holding that same **RED** wire connector, and gently pull the red wire out of the black 8-pin connector. Do the same for the **BLACK** wire connector next to red. You should now have two empty "slots" at the bottom of the 8-pin cable connector. Repeat the process for the plug on the opposite end of the cable, so that you have two loose wires (one RED and one BLACK) and the remaining 6 wires still attached to the black connector ends.
    e. For the remaining 6 wires, cut them off close to the connector that will NOT be plugged into the VIC-II² card. This should leave a black connector on the VIC-II² card side with six of the remaining eight wires attached to it, and two empty "slots" at the bottom.
    f. Using a wire stripper, remove about 3/16" of insulation from the cut end of each of the remaining six wires of the cable; try to keep the "wrapped" shape of the cable, as this will make it easier to work with later
    g. Carefully twist the bare end of each wire so that the smaller wires come together

   h. Using the soldering iron, “tin” the end of each wire, applying a small amount of solder to the end of each wire to keep the smaller wires inside together and aid in connecting to the switch and test hook clips

2. Prep the Test Hook Mini-Grabber Cables with DuPont Headers
   a. Take two of the Test Hook Mini-Grabber Cables with DuPont Headers
   b. In the same way that you did above, using the tip of an XActo blade or fine metal pick, carefully lift the small black retaining tab holding the wire of the Test Hook Mini-Grabber in the DuPont connector, and gently pull the wire out of the black DuPont connector. Do the same for the second wire of the second Test Hook Mini-Grammer connector.
   c. Insert these connectors into the empty “slots” on the 8-pin connector, ensuring that the “latch” engages and keeps these wires in place. If not, twist the wire 180 degrees and insert with the other side facing up.
3. Prep the Shrink Tubing
   a. Cut 1 @ 2” length of 3⁄4” shrink tubing and slide all the way onto the 8-pin cable
   b. Cut 1 @ 1” length of 1” shrink tubing and slide all the way onto the 8-pin cable
   c. Cut 6 @ ¾” lengths of 3/16” shrink tubing and slide each about 2” onto the grey, brown, white, blue, green, and yellow wires of the 8-pin cable
4. Solder the Wires
   a. On the six remaining wires of the 8-pin connector (usually grey, brown, white, blue, green, and yellow), create a small loop in the tinned end of each wire using the small needle-nosed pliers

      YOUR WIRE COLORS MAY DIFFER FROM THOSE SHOWN IN THE DIAGRAMS. GO BASED ON THE POSITION OF THE WIRE, NOT THE COLOR!

   b. Thread each loop of the remaining wires on the 8-pin cable through the small holes on the posts at the bottom of the DPDT switch according to the diagram below
   c. Solder each wire loop to it’s post, ensuring good solder connectivity between post and wire without excessive solder on the connection

5. Cover the Solder Joints
   a. After the solder has sufficiently cooled on the switch, slide each of the 6 @ 3/16” pieces of shrink tubing up the wire to cover the end of the wire and it’s switch post
   b. Using a controlled heat source (lighter or heat gun) shrink the six pieces of shrink tubing over the solder joints on the bottom of the switch, taking care not to prematurely shrink the other pieces yet
   c. Once those pieces of shrink tubing have cooled, slide the 1 @ 1” piece of shrink tubing up the 8-pin cable to cover all the bottom posts of the switch, and shrink the tube with a controlled heat source
   d. Once that piece of shrink tubing has cooled, slide the remaining 1 @ ¾” shrink tubing up the 8-pin cable to cover the bottom of the now-shrunk 1” tubing, and shrink the tube with a controlled heat source
   e. Allow the whole cable to cool, remove it from the VIC-II² board, and set aside for later installation

Motherboard Headers

We're done for now with building components, so now we have to go back and add female headers to the C64 motherboard.

Aligning all the female headers at once can be tricky. You may find it easier to break this into steps, soldering one set of female headers at a time:

1. Clear your workspace and get your soldering iron ready and preheated to 600° F
2. Bring the C64 motherboard back to your workspace and also have the VIC-II² card ready
3. Find the 40-pin female machine pin headers from your components, cut off a 3-pin section, and insert them onto the three crystal header pins on the back side of the VIC-II² card
4. Cut off three single-pin female headers from the remaining 37-pin female machine pin headers
5. Insert one of these single machine pin headers on each of the PAL/NTSC headers on the back side of the VIC-II² card (3 on the RED card, 2 on the BLUE card)
6. Ensure that the female headers are pushed fully onto the male header pins with no gap between the header and the black plastic separators; all headers should be straight and perpendicular to the back of the VIC-II² card
7. Taking the VIC-II² card in one hand and the C64 motherboard in the other, carefully insert the pins from all female machine pin headers on the back of the VIC-II² card into their corresponding holes on the top side of the C64 motherboard; MAKE SURE ALL PINS POKE CLEANLY THROUGH THE HOLES SO THAT THE PINS CAN BE CLEARLY SEEN
8. Holding the VIC-II² card firmly against the C64 motherboard, flip the motherboard over to the bottom, and solder the machine pin headers in place, ensuring that the VIC-II² board remains tightly pressed against the C64 motherboard
9. Check occasionally to ensure that there are no gaps between the metal "caps" of the female machine pin headers and the front side of the C64 motherboard
10. Make sure all 5 or 6 solder points (3 on the crystal, 2 or 3 on the PAL/NTSC jumpers) have good "tenting" and that adjacent pins/pads are not joined with solder
11. Using IPA (isopropyl alcohol) or circuit board cleaner, remove all flux or solder debris from the bottom of the C64 motherboard

Remove and Reinstall VIC-II² Board on Motherboard

Your VIC-II² card is now attached to the C64 motherboard, but since we installed header pins, you should take the time now to remove and re-attach the VIC-II² card a couple of times. This can be done by carefully inserting a flat-bladed screwdriver beneath the VIC-II² card from one side of the VIC-II slot and lifting slightly. Be sure to avoid the motherboard components near the VIC-II socket. Alternate this from both sides of the VIC-II slot until the card comes off. Your female DuPont headers should remain firmly in place on the motherboard. After you have done this a few times, re-insert the VIC-II² card onto the C64 motherboard one last time.

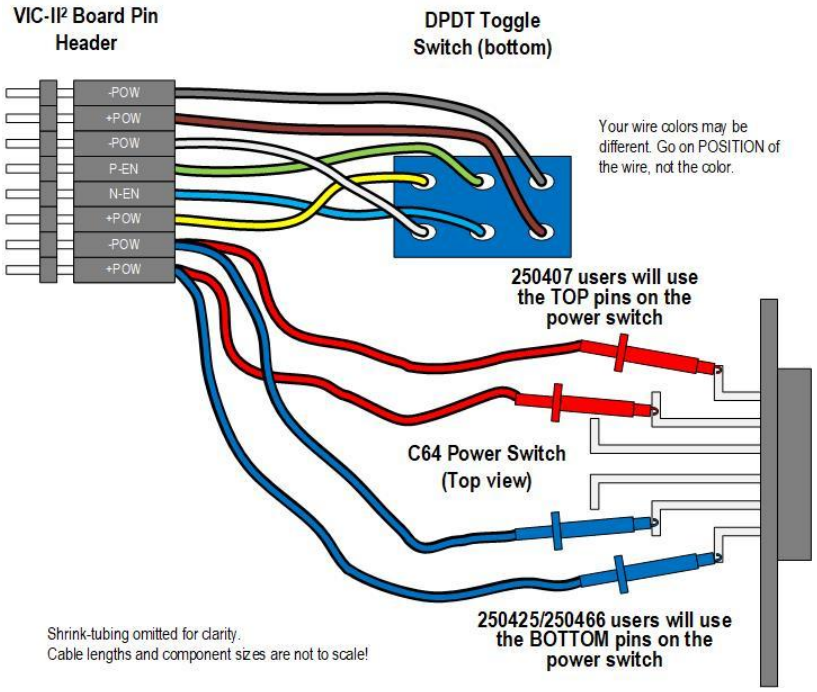
Connect VIC-II² Switch Cable

Depending on where and how you'll be exposing the DPDT switch outside of your C64 case, set it in place and attach VIC-II² switch cable to the 8-pin header, ensuring that the bottom test-hook wire is at the bottom of the connector, closest to the NTSC crystal. The switch WILL work if installed upside down, but it will function oppositely. For consistency, keep the bottom test-hook wire down and the SMOOTH side of the cable UP.

Connect VIC-II² Hook Clips to Power Switch

To get the relays to toggle between NTSC and PAL, they must have power. Fortunately, they are latching relays, so they stay in the last position they were in until switched. This switching must ONLY happen when the power is turned off (don't want to damage those delicate VIC-II chips!), so we must take power from the power supply BEFORE it comes through the C64 power switch.

You'll be attaching the test hook clips to the C64 power switch according to the diagram below. The C64 power switch is on the upper right side of the motherboard, just below the power port. The test hook clips work by squeezing a "plunger" at the end (wire side) of the clip so that a small hook (or pair of "tweezers") protrudes from the end and can be clipped around a wire or component leg.



If you have a 250407 motherboard (RED VIC-II² board) follow THESE instructions:

Clip the test hook clip attached to the bottom wire of the cable to the **UPPER** middle leg of the C64 power switch. Ensure that the plastic part of the clip can still fit within the C64 case when closed. Ensure that the clip stays firmly attached to the leg once pressure has been released from the plunger. This leg of the power switch has NO power when the switch is OFF and +5v when the switch is ON.

Clip the test hook clip attached to the second from the bottom wire of the cable to the **UPPER** right leg of the C64 power switch. Again, ensure that the plastic part of the clip can still fit within the C64 case when closed. Ensure that the clip stays firmly attached to the leg once pressure has been released from the plunger. This leg of the power switch has +5v whether the switch is ON or OFF.

If you have a 250425/250466 motherboard (**BLUE** VIC-II² board) follow THESE instructions:

Clip the test hook clip attached to the bottom wire of the cable to the **LOWER** middle leg of the C64 power switch. Ensure that the plastic part of the clip can still fit within the C64 case when closed. Ensure that the clip stays firmly attached to the leg once pressure has been released from the plunger. This leg of the power switch has NO power when the switch is OFF and +5v when the switch is ON.

Clip the test hook clip attached to the second from the bottom wire of the cable to the **LOWER** right leg of the C64 power switch. Again, ensure that the plastic part of the clip can still fit within the C64 case when closed. Ensure that the clip stays firmly attached to the leg once pressure has been released from the plunger. This leg of the power switch has +5v whether the switch is ON or OFF.

Install VIC-II Chips & Heat Sinks

Now you can FINALLY install your VIC-II chips into the VIC-II² card. Ensuring you're properly grounded from static, remove the VIC-II chips from their protective packaging and install them into the appropriate socket on the VIC-II² card, noting that the notch at the top of the chip should align with the notch on the printed outline of the chip on the card. You may need to add some leverage to the opposite side of the card to keep it balanced in the real VIC socket below. Take your time to carefully install these chips, ensuring that the pins are not bent or damaged in the process. As these chip sockets are new, the VIC-II chips should both sit cleanly and firmly in place. Give one last firm but gentle push onto the tops of each chip to ensure they are seated.

These VIC-II chips can get VERY hot, and we've just removed the only heat-management option we had (the RF cage). If you don't already have a heat sink for your VIC-II chips, you need to cover the middle 40mm/1.5" of the VIC-II chips to properly dissipate heat. Note that these heat sinks SHOULD fit under the C64 keyboard when the case is put back together.

The center of the VIC-II chips gets the hottest, as that is where most of the circuitry is. I recommend putting two of the self-adhesive heat sinks on each VIC-II chip, positioned as closely together as you can.

Take one more look at the VIC-II chips to ensure that they are seated, that the VIC-II² card is firmly seated as well, that the VIC-II² cable is firmly attached to the pin headers, and that the metal switch body and toggle are NOT touching any exposed part of the C64 circuitry.

Plug in C64 Motherboard & Test

With the C64 motherboard still OUTSIDE of the case, make sure the power switch is turned OFF (down). Plug in the monitor cable and ensure your monitor/TV are turned on and set to the proper input. Remember that your monitor MUST be capable of operating in BOTH PAL and NTSC modes to properly test this modification.

Next plug in the C64 power supply cable, first to main power, and then into the motherboard. You might hear a CLICK from the relays on the VIC-II² card. This is okay.

If you hear any electrical buzzing, see any smoke, sparks, or other electrical issues, immediately unplug the C64 from the power supply! Check all of your work up to this point and try again.

Now, with the C64 still switched OFF (down), toggle the VIC-II² card switch. You should hear the relays switch (click). Try this a few times to make sure it clicks in both positions of the switch.

You can now test the C64 under full power in one of two ways: with a test cartridge or without. As suggested earlier, I recommend using a "dead test" cartridge installed in the cartridge port but testing at the default "blue screen" is fine as well. Turn the C64 power switch ON (up) and watch for any problems.

If you hear any electrical buzzing, see any smoke, sparks, or other electrical issues, immediately turn off the C64 and unplug it from the power supply! Check all of your work up to this point and try again.

If your monitor identifies which mode you are in (PAL or NTSC), take note of this. Turn off the C64, flip the VIC-II² card switch (relays should click again), turn the C64 back in, and see if the monitor indicates the other mode from the one before.

If it doesn't, you can turn the C64 off, remove the test cartridge, and reboot to the blue screen. Then, type the following command in, and press RETURN:

```
? PEEK (678)
```

If you're in NTSC mode, it should reply "0". If you're in PAL mode, it should reply "1". Try this in both modes of the VIC-II² switch (turn off C64 in-between), and make sure you get different results in both positions of the switch.

There are other ways of testing this which I won't go into here. Check your favorite C64 forum or user's group for tips on software that behaves differently between NTSC and PAL mode.

Lumafix Adjustment

If you've installed the Lumafix circuitry, you'll want to now adjust the blue trim pots. Note that Lumafix doesn't have much effect on CRT monitors. Usually, only LCD, LED, or plasma digital monitors benefit from Lumafix.

With the C64 still turned on and in your preferred video mode, with a small flathead screwdriver (plastic is best, but if you touch a metal one to the cartridge port metal shield first you should be fine) start by turning both pots ALL THE WAY CLOCKWISE (you will hear a clicking sound when you reach the end). This setting usually produces A LOT of vertical lines, so don't be alarmed. Beginning with the TOP or RIGHT pot, slowly turn COUNTER-CLOCKWISE until most of the vertical lines disappear. When the level is as good as you can get it, continue with the BOTTOM or LEFT pot, slowly turning COUNTER-CLOCKWISE until the remaining vertical lines disappear. Most users have best results when both pots are at or near FULL COUNTER-CLOCKWISE (again, clicking sound), but the sensitivity of your C64 and monitor may vary.

Once you're done testing, turn off the C64, unplug the power and monitor cables (and anything else you may have plugged in like the test cartridge), and get ready to reassemble the case.

Reassembly

CONGRATULATIONS, you've completed the installation! Now comes the easy but tedious part. Like many techies, I'm superstitious about putting a computer back together before it's been tested for fear of tempting fate. But reassemble we must…

Motherboard Installation

Get the bottom of the C64 case and the seven small screws for the motherboard. Carefully put the motherboard with the VIC-II² card into the case, maneuvering the VIC-II² switch to whichever opening in the case you want (or mounting hole, if that is your choice). Starting in the upper right corner, carefully install and tighten the first motherboard/case screw, taking care to NOT OVERTIGHTEN. Next, install the screw in the corner OPPOSITE of this, in the lower left corner, again taking care to not overtighten the screws. Now proceed to install each of the five remaining screws.

Take time to make sure all cables (particularly the test hook clips) are will not interfere with the case closing, and that they are still making good contact with the legs of the power switch.

Keyboard Installation

Get the top of the C64 case (keyboard should still be attached) and plug the keyboard cable into the motherboard (upper left side). Next, attach the 3-pin LED cable to the header at the lower right side of the motherboard. Carefully set the back edge of the top of the case into the tabs at the rear edge of the bottom of the case. Slowly tilt the top forward to close the two halves of the case. The case should be neatly together with nearly no gap at the edges, otherwise, gently push the two halves together until they pop into place

Holding both halves together, flip the C64 so that the keyboard is facing down and get the three case screws. Install the screws in the three holes on the bottom front edge.

Flip the assembled C64 over into the standard operating position.

Plug in the Main Components

Plug monitor and power supply cables back in and perform the same tests as before on your newly-assembled C64 unit.

Plug in Everything Else

Once everything works, then you can reattach additional peripherals.

BOOYAH! You're done!

Maintenance

That's it! Your VIC-II² card should serve you well for years to come! The system will be easy to maintain so long as you follow a few instructions.

NTSC/PAL Switching: Best Practices

While the VIC-II² switch can be toggled when the system is on, it will not switch modes until power has been switched off (A RESET/REBOOT WON'T TRIP THE RELAYS). It is best practice to turn the system OFF first, then flip the VIC-II² switch, then turn the C64 back on.

Troubleshooting & Support

Q: "I hear a buzzing/chattering when I plug the C64 in"
A: Unplug the C64 immediately. Change your hook clips to the other side of the C64 power switch as illustrated. If you're using a 250407 board (RED VIC-II² board), they should be on the TOP middle and TOP right pins of the C64 switch as illustrated earlier. If you're using a 250425/250466 board (BLUE VIC-II² board), they should be on the BOTTOM middle and BOTTOM right pins of the C64 switch. We still have no idea why Commodore decided to change this between the two versions of the motherboard...

Q: "One mode displays a black & white picture"
A: Are you 100% sure your monitor/TV supports that mode (PAL or NTSC)? As per the notes on the purchasing webpage, your screen must support both PAL *and* NTSC. While our product can switch the computer's mode, it cannot create a mode inside the monitor that the monitor does not support. Some televisions that are capable of displaying both modes are actually region-locked, and will only fully support the region for which the TV was manufactured. A way around this is to use an upscaler that supports both PAL & NTSC, such as the Framemeister XRGB Mini or the VCando SCART to HDMI converter (with either a composite to SCART cable or a SCART to composite adapter). There is a little lag with the VCando solution, and the 12v power port is VERY close to the SCART port, so some wide SCART adapters/cables can require a little trimming of the sides to get both to fit. However, for about US$50, it is a more affordable option than a full-blown upscaler. Another great upscaler priced between the two is the Retrotink, although we haven't yet confirmed it solves the problem.

🏆 Framemeister XRGB Mini: https://ebay.to/2ZmQyOR

🥈 Retrotink: http://www.retrotink.com

🥉 VCando: https://www.amazon.com/dp/B01N06Q9WH

Q: "My monitor supports PAL & NTSC but one mode is still black & white"

A1: If you have C64 Assy. No. 250407: In this case you can still find success by installing a 7pF ceramic capacitor in place of the 16pF ceramic capacitor at the position marked "C70" on the Commodore 64 motherboard. You'll find this extra capacitor included with your VIC-II² kit at no extra charge. To replace it, you'll first have to carefully remove the installed VIC-II² card from the C64 to have access to C70 for desoldering and replacement. Install the replacement capacitor and re-test.
You can find a video about this process here: https://youtu.be/pw6xcDPcSQM

A2: If you have a C64 Assy. No. 250425: Locate the trimpot marked "CT1" on the Commodore 64 VIC-II circuit. You will need to remove the VIC-II² to access this. Adjust it 3/8ths of a turn counter-clockwise, reinstate the VIC-II² and test. If you still have a B&W image, remove the VIC-II² again and experiment with other small adjustments to CT1 until color appears.

Q: "The system won't switch modes"
A: Check to ensure that the hook clips still maintain electrical contact with the leads on the power switch; if desired, these hooks can be removed, and the wires more permanently soldered to the pins on the power switch.

Q: “The system displays garbage or a black screen”
A: Ensure the VIC-II² card is firmly seated on the motherboard (all header pins!), and that BOTH VIC-II chips are also firmly seated in the properly oriented position.

Q: "I have vertical stripes (jailbars) on the screen"
A: The blue trimpots will remove these if turned with a watch screwdriver, but may have to be turned a very long way. This is so you can choose more accurate settings than using trimpots with short travel. Try turning them fully counterclockwise by several rotations and experiment from there.

Further support:
This VIC-II² is sold as-is and without direct support which would increase the price. Please kindly reach out to the community and the developers via this webpage only: http://bit.ly/vicii2