SEGA Master System 2 Jailbar fix

Based on research performed by Leah Rowe (twitter @n4of7) of RetroFreedom.com

Sega Master System (and Mega Drive / Genesis) consoles are known to be noisy on the analog video outputs. The most common discussion on both the Master System and Genesis/MegaDrive is of “jailbar noise” or “sega stripes”, which are faint vertical lines across the screen. They’re more noticeable on PVMs, or digitizers such as Framemeister or OSSC. This guide will tell you how to mitigate them!

If you followed the old guide, note: cutting pin 6 of Z80 CPU is incorrect. Reverse Z80 pin 6 cut (Z80 clock is also routed to a pin on the cartridge slot). We discovered game glitch issues with the separate oscillator. Use a clock divider from VDP pin 35 instead (divide it by 3), but still cut VDP pin 33+34.

WARNING: French SMS2 is not covered by this guide. The circuitry is quite different. You must adapt these instructions accordingly. Contact Leah @n4of7 on twitter to sell your French SMS2 (ideally with Adapteur RVB included) so that it can be studied; instructions will then be adapted for this guide.

These mods require excellent soldering and de-soldering skills. If you are not at all confident in your skill set, it is recommended that you hire a competent technician to perform these modifications.

List of materials plus list of precautions:

BE SURE TO TURN YOUR CONSOLE **ON** BEFORE DISASSEMBLING IT, then unplug the power cable with the power switch set to the "ON" position. This will ensure that any capacitors in the board are fully discharged, and then you can begin disassembly. Then, make sure the board is not connected to any power sources when working on it or during disassembly/reassembly.

- **Use an anti-static / ESD strap. Wear it on your wrist.**
- **Low humidity environments increase harmful ESD, but high humidity creates moisture.** An environmental humidity of 25-30% is ideal. Buy a humidifier if you live in a country with low humidity (e.g. Portugal) or de-humidifier in high humidity environment (e.g. Thailand,Vietnam).
  Humidity is extremely important when working on exposed circuit boards.
- **Decent soldering and vacuum de-soldering equipment**: **Hakko** brand (used, on eBay, for good price) is recommended. Don't use cheap Chinese rubbish! (unless it's made by AOYUE!)
  DO NOT use Weller stations. EEVblog showed that some of them don't have fuses for AC input

  If you already have a good soldering iron, but need a de-soldering vacuum, we recommend the ZD-915. It comes under many brand names. ZD-915 is inexpensive but does a good job.

- **Type of soldering tip recommended: knife tip**. Do not use the pencil type tip. Mini chisel or thick conical / bent J tip can also work if you have those (if RGB mod without bypass on Sonic1 SMS2, J tip is recommended for soldering to pins on MB3514 video encoder) but a knife tip will be ideal for SMS2 boards.

  *****MAKE SURE***** that **ALL** soldering equipment you're using is **ESD safe**.

- **Lab-grade 99.9% isopropyl alcohol.** Use with soft anti-static bristle brush to clean the board thoroughly; you can't get a good solder joint on a dirty surface!

- **Good quality 28awg STRANDED COPPER**

  28awg hookup wires **are recommended for analog video lines. Most will have PVC insulation so you have to be careful not to melt the insulation when soldering.** In general, you should use 28awg exclusively, when working on SMS2 consoles.

  This is EXTREMELY important. Using thinner wires such as 30awg will result in voltage drops on the RGB lines, which can cause ghosting issues. However, thicker gauges such as 24 or 26 awg can pick up more RF/EM noise. 28Awg is an ideal wire gauge for short wire runs on analog video lines (on longer runs, we recommend **shielded** coax specifically rated for 75ohm transmission)

- **Use quality ROSIN (non-acidic!) flux when soldering**. Flux, when hot, removes oxides and prevents further oxidation. Surface oxides obstruct getting a good solder joint. Apply it on the points you're soldering to. Also use it when tinning the stripped wires. Pasta do Lutowania is an EXCELLENT brand of non-acidic rosin flux, from TermoPasty and it is ideal for soldering with: https://termopasty.pl/produkty/pasta-do-lutowania/

- will **Use quality 60/40 leaded solder.** NEVER use lead-free solder! Also, make sure that it's flux-cored (ROSIN flux, NOT acid flux. Acid flux should NEVER be used on electronics).
- **THS7374 RGB Bypass board (not required for Sonic1 SMS2 consoles):** The Mega Drive / Genesis RGB bypass board from Voultar LLC is recommended, due to its simplicity. This board is "opensource" and available on OSHpark to purchase, manufactured at their PCB factory. To assemble, you will need to also source the THS7374 chip and relevant resistors/capacitors: https://oshpark.com/shared_projects/8Mmjnlst

  Alternatively, voultar.com sells it pre-assembled, or (if you live outside of USA) you can buy the board preassembled on https://videogameperfection.com/

  NOTE: The jailbar fixes can be performed on French SMS2 but RGB mod is not necessary on that model, because French SMS2 already outputs RGB to an included DIN socket. Output is done directly from VDP to DIN, and the Adapteur RVB SCART cable has a box in it with circuitry for amplifying and attenuating the RGB/sync signals. RGB bypass **might** be beneficial on that console, to cause compatibility with **shielded** RGB SCART cables like the ones sold on **retrogamingcables.co.uk** or **retro-access.com**

- **AV Out connector (9 Pin miniDIN, 8 Pin DIN etc). DIN8 is recommended**, due to its superior mechanical reliability. We recommend wiring for the same pinout as MegaDrive 1 DIN8 socket (look up the pinout online), or the same wiring as megadrive2 if using miniDIN. A DIN8 plug can be purchased here: https://console5.com/store/premium-din-connector-socket-8-pin-panel-mount-solder-lug-262-u-style.html
  (other stores also sell it. Look at the picture on that page, to know what it looks like)

- **3x 10µF 16V electrolytic capacitor (polymer capacitor is probably OK),** for audio and for power filtering on the VDP.

  NOTE: When buying electrolytic capacitors, we recommend buying quality **JAPANESE** brands such as Nichicon, Rubycon and Panasonic. Rubycon is the best quality brand, by far, but the other two are also good. ONLY buy from reputable sellers such as Mouser, Farnell/element14 and… actually those are the only two suppliers we recommend. NEVER buy chinese capacitors (***crap****acitors*). **STAY AWAY FROM ALIEXPRESS/EBAY/AMAZON!!** The reasons are explained here: https://www.badcaps.net/index.php?pageid=causes

  You may want to simply purchase an entire cap kit for your SMS2. ***Console5.com*** sells them, and has lists of capacitors. You should DEFINITELY re-cap your power supply! An official Sega PSU (which we recommend greatly) uses a 3300uF 16v capacitor for ripple filtering on the DC rectifier circuit. Panasonic in particular sell VERY high quality 3300uF capacitors. **MAKE SURE THAT THE CAPACITOR IS RATED FOR AT LEAST 16V, because the LM7805 voltage regulator in your SMS2 is rated to handle between 9V to 15V input voltage, according to the datasheet. The transformer+rectifier circuit in Sega's PSU generates 9V for SMS2 PSUs and 10V for Sega Genesis/MegaDrive PSUs which are compatible with SMS2. In general, the ripple capacitor in a PSU should ALWAYS be rated far higher than the voltage that will actually be used, due to the possibility of voltage spikes.**

- **Crystal oscillator(s) <u>or clock divider (to divide a given frequency by 3)</u> for jailbar fix :**
  NOTE: When we say "crystal oscillator", we mean the 4-pin variety. DO NOT purchase the 2-pin ones. The 2-pin crystals are often advertised (WRONGLY) as crystal oscillators, but they are only crystals and they lack the oscillator circuit. YOU CAN use those 2-pin crystals but then you need to build the oscillator circuit externally. For simplicity, buy a full 4-pin crystal oscillator IC.

  For NTSC consoles:
  Only buy 3.579545MHz crystal oscillator (for Z80 CPU clock input)
  For PAL/Brazil consoles, if wanting to mod for true 60Hz NTSC timing:
  buy 53.693175MHz (to replace 53.203mhz master clock) **and** 3.579545MHz crystal oscillators as the 53.693175MHz master clock is *required* if using 3.579545mhz oscillator for the CPU.

  SMS2 / VA3 SMS1 on 315-5237 IC divides the master clock (53.69) going into pin 43 and divides by 5 (via internal clock divider) to create a roughly 10.7mhz clock, which is outputted from pin 41 and into VDP (315-5246) pin 35 which is the VDP's clock input pin. VDP then divides this by 3 (via internal clock divider) to create a 3.58mhz clock which is outputted via pin 33; this is fed into the Z80 CPU clock input on pin 6, and into cartridge connector pin 47. This is the MAIN cause of jailbars; later in the guide, we will tell you to cut VDP pin 33 and directly hardware a separate 3.58mhz oscillator output to Z80 CPU pin 6. The VDP's internal clock divider circuit is very near to the analog RGB circuitry, which is why this causes so much jailbar noise.

  <u>A note about why we recommend clock divider. To divide frequency by 3:</u>

  Some games will slightly glitch with this mod. This is because of tight timing needed between VDP and Z80 CPU. Not all crystals are the same frequency, versus their rated speed. Slight discrepancy caused by this means that the VDP and CPU will run slightly out of sync. It shouldn't cause any games to crash, but on some games you might show random sprites and other glitches, usually for only a split second; it is merely distracting, but of course it means that execution is no longer fully accurate. We recommend cutting pin 33 on VDP and, instead of 3.58mhz oscillator directly to pin 6, connect clock divider reference input to VDP pin 35 or 315-5357 IC pin 41; this clock divider must divide by 3 to produce an output of 3.58mhz.

  TODO: draw a circuit here and test such a circuit

<u>Now onto the step by step guide</u>

We will believe in you for 30 minutes. Your katamari needs to be 200m

Step 1 (skip if you have NTSC SMS) – Convert PAL console to 60Hz

These steps show how to get proper NTSC timings. Specifically: 15.69kHz hsync and 59.91Hz vsync

1. VDP (315-5346 IC) pin 57 sets the SMS2 to 50Hz PAL timings if connected to +5v. If connected to ground, your SMS2 will boot with 60Hz NTSC timings. Most people will simply cut this pin, but this is not recommended because it weakens the mechanical reliability.

   There is a trace connecting the pin to +5V. On SMS2 consoles this trace is running under the pin, but it is visible to the eye. Cut the trace, and verify that the pin is successfully isolated; check on a multi-meter in continuity mode, and verify whether or not you can buzz it on +5V

   THIS IS VERY IMPORTANT. If you don't isolate it, and then ground it, and boot your SMS2, there will be a short circuit between +5V and GND. This could blow the main 7805 voltage regulator. It could even cause a fire. MAKE SURE THAT THE PIN IS FULLY ISOLATED!

   If you've verified that the pin is isolated, now connect it to a nearby ground source. E.g. pin 24 on the chip labeled 315-5237.

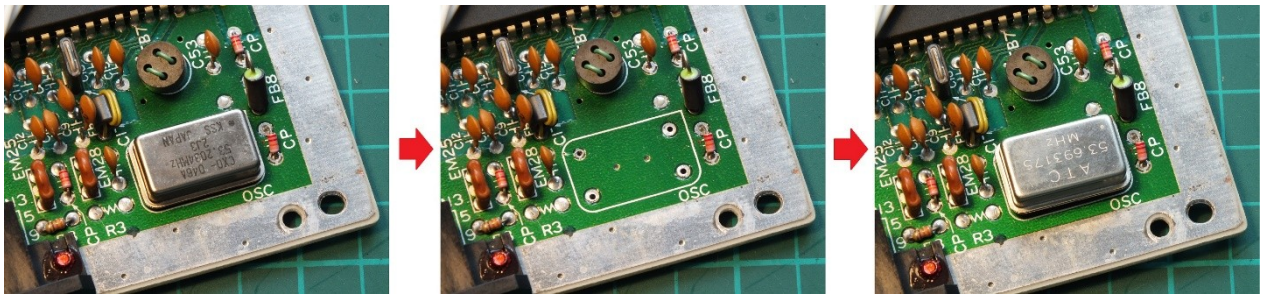
2. Desolder the 53.203MHz crystal oscillator from the motherboard and solder the new 53.693175MHz crystal oscillator in its place.

   NOTE: Some French SMS2 consoles already have the 53.69mhz master clock!

   This video shows how to properly use an extractor tip when de-soldering: https://www.youtube.com/watch?v=e8KRPFOD1RE
   That video is from a series of soldering related tutorials from PACE Incorporated. It's good stuff! They're very old but for master systems, those videos are perfect if you want to learn how to do mods properly.

   We recommend fluxing the oscillator joints, then flow fresh solder into them. This lowers the melting temperature (if you're using 60/40 leaded solder) and eliminates surface oxides; it also ensures adequate thermal mass, allowing easy de-soldering.

The following photos shows the oscillator being replaced!



It’s too early to feel safe.

Step 2 – Removing the primary source of jailbars

We will bypass the Z80 clock signal going from the VDP (IC 5) to the Z80 chip (IC 1). By default, 53.2/53.69mhz master clock feeds to 315-5237 and gets divided by 5 to create 10.73mhz which feeds into the VDP's clock input on pin 35. The VDP (315-5246) divides that by 3, internally, and outputs 3.55 or 3.58mhz (depending on master clock) to Z80 CPU clock input on Z80 pin 6. **You should have already replaced the master clock with 53.69mhz oscillator if modding a PAL console. This means that the CPU clock will be 3.58mhz instead of 3.55mhz. Even in PAL mode, this is OK (French SMS2 consoles have 53.69mhz oscillator even though they are intended for PAL games, and some of them even have a 50/60hz switch wired to pin 57, put there by Sega themselves). The only time the 53.2mhz oscillator is useful is if you intend to have a 3.55mhz CPU clock and 4.43mhz PAL subcarrier for the video encoder, if using composite video, which would defeat the purpose of this guide.**

This clock divider circuit within the VDP is implemented VERY CLOSE TO the digital to analog circuitry and analog RGB output pins on the VDP, and is the MAIN cause of jailbar noise on SMS2 consoles! The same is true of VA3 SMS1 consoles, but this problem may also exist on older SMS1 consoles that use a different VDP (a separate guide for older SMS1 consoles will be written at a later date, after sufficient research / reverse engineering and *mad science* has been completed).

To make matters EVEN WORSE, SMS2's VDP then outputs that 3.55/3.58mhz clock via a trace that runs ALONGSIDE the traces for RGB and CSYNC fed from the VDP to the video encoder. It's as if Sega WANTED the ABSOLUTE WORST picture quality on SMS consoles! It's mind boggling!

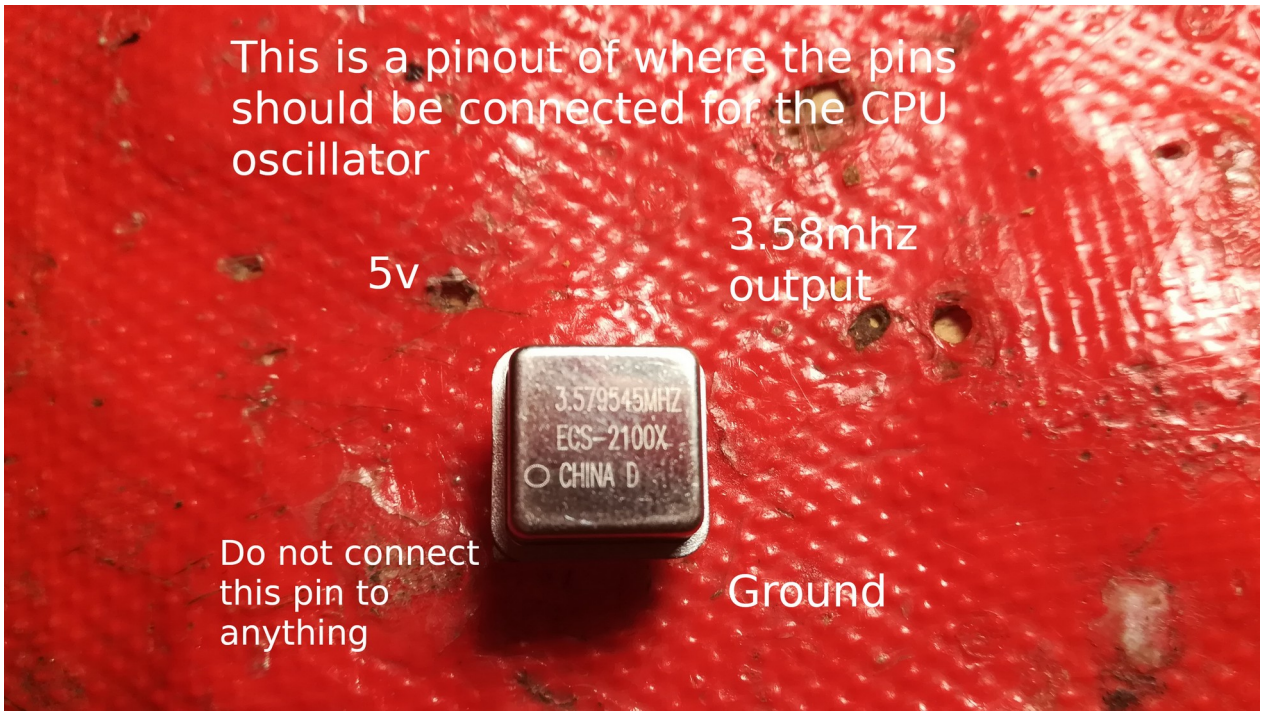
Here's how to work around Sega's stupidity, and (for the most part) eliminate jailbars!

1. **Cut pin 33 of the VDP (IC 5)**. Just cut it. No need to connect anything! **VDP is the chip labeled 315-5246.**
2. **ALSO cut pin 34 on VDP.** Pin 35 is the clock input, labeled XTAL1 in schematics. Pin 34 is labeled XTAL2; French RGB SMS2 uses a 2-pin crystal feeding into the VDP, which is what XTAL2 is for. On PAL and NTSC SMS2 consoles, pin 34 is unused and is grounded via capacitor. Cutting pin 34 reduces noise by reducing the amount of clock circuitry in use internally. The reason this matters is because the clock circuitry is all very near to the analog RGB circuitry within the VDP.
3. **Remove C23 from the SMS2 mainboard. This is a filter capacitor to ground for VDP clock pin33. C23 should be moved to cartslot pin 47 and other side soldered to ground. If C23 is left in it's default location, the jailbars will still be present even after cutting VDP pin 33, because the CPU clock 3.58mhz will run on a trace alongside RGB traces coming off of VDP, in order for it to reach that capacitor and short to ground. Removing this capacitor solves the problem.**
4. **Cut all traces near and leading to cartridge slot pin 47. After doing that, solder a wire between cartridge slot pin 47 and Z80 CPU pin 6; do this on the solder side of the board, but be sure not to route it near any analog video/audio lines.**
5. **Hard-wire the oscillating clock output of a 3.58mhz crystal oscillator to Z80(IC1) pin 6:**

NOTE: Not all crystals have the same frequency. Two crystals both rated 3.579545mhz will each have slightly different frequencies in reality; they will be close to the rated spec, but it's give or take a small amount. It is **never precise.**

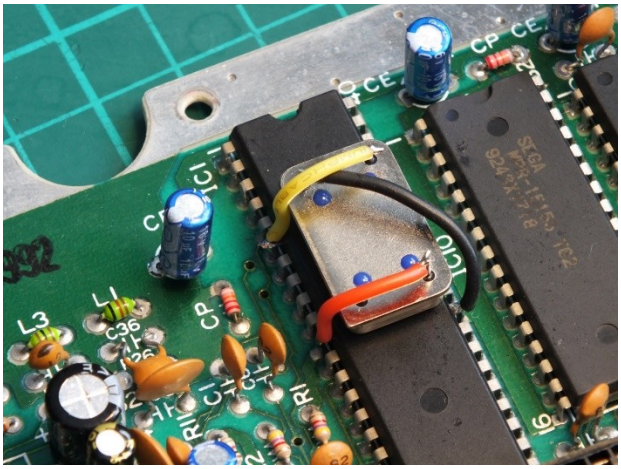
If you have the parts (flip flops and some gates. Look up circuit online), use instead a clock divider that divides a given frequency by 3. Wire this to 315-5237 pin 41 which is for the VDP input clock (~10.7mhz); input is then to be divided by 3, with the resulting divided clock of 3.58mhz inputted into Z80 pin 6. *We do not yet have documentation for clock divider circuit, but this guide will be updated at a later date to recommend a solution. This will ensure glitch-free gaming due to perfect timing sync between VDP and CPU.*

Pinout of oscillator, please observe:

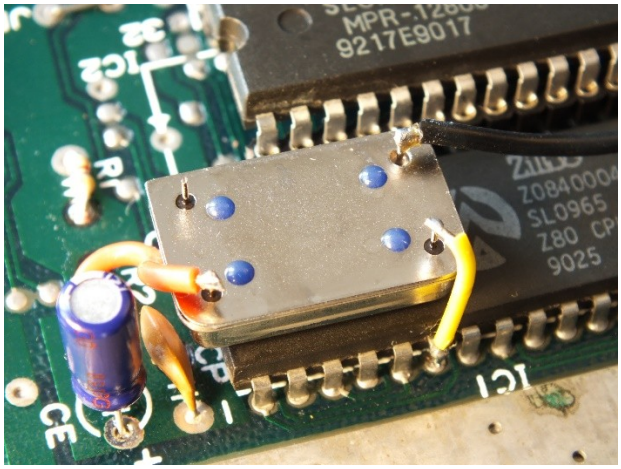


If you hard-wire a separate 3.58mhz oscillator to CPU pin 6, there will be an almost negligable timing discrepancy between CPU and VDP after doing this. In practise, games will be playable but you may occasionally see random garbage sprites appear in random places on the screen, but these glitches will only be visible for a split second when it occurs. We have not discovered any games that crash or otherwise become unplayable due to this anomaly, but sticklers for accuracy may not like it; if you are such a person, either use a clock divider instead or just don't do the jailbar fix and use a CRT where the jailbars are barely visible. Cutting Z80 pin 33 and re-routing the link to CPU pin 6 so that the clock wire isn't running alongside the RGB lines, and removing C23, will already reduce jailbars though not quite as much as the full jailbar fix. This slight glitching issue does not exist with the default 3.58mhz output of the VDP (fed into CPU clock input) because it is a perfect division of the master clock (master clock divided by 15, but in reality it's VDP clock divided by 3, where VDP is master clock divided by 5).

BE CAREFUL! The metallic casing on the oscillator is ground. MAKE SURE after installing the oscillator that the 5v voltage plane and ground plane is not short circuited! Short-circuit between 5v/GND == FIRE



(Master System 2 example)



(Master System 1 example)

If you already made it this far, I don't know what to say to you. Good job! But you're not out of the woods yet. PROCEED AT YOUR PERIL.

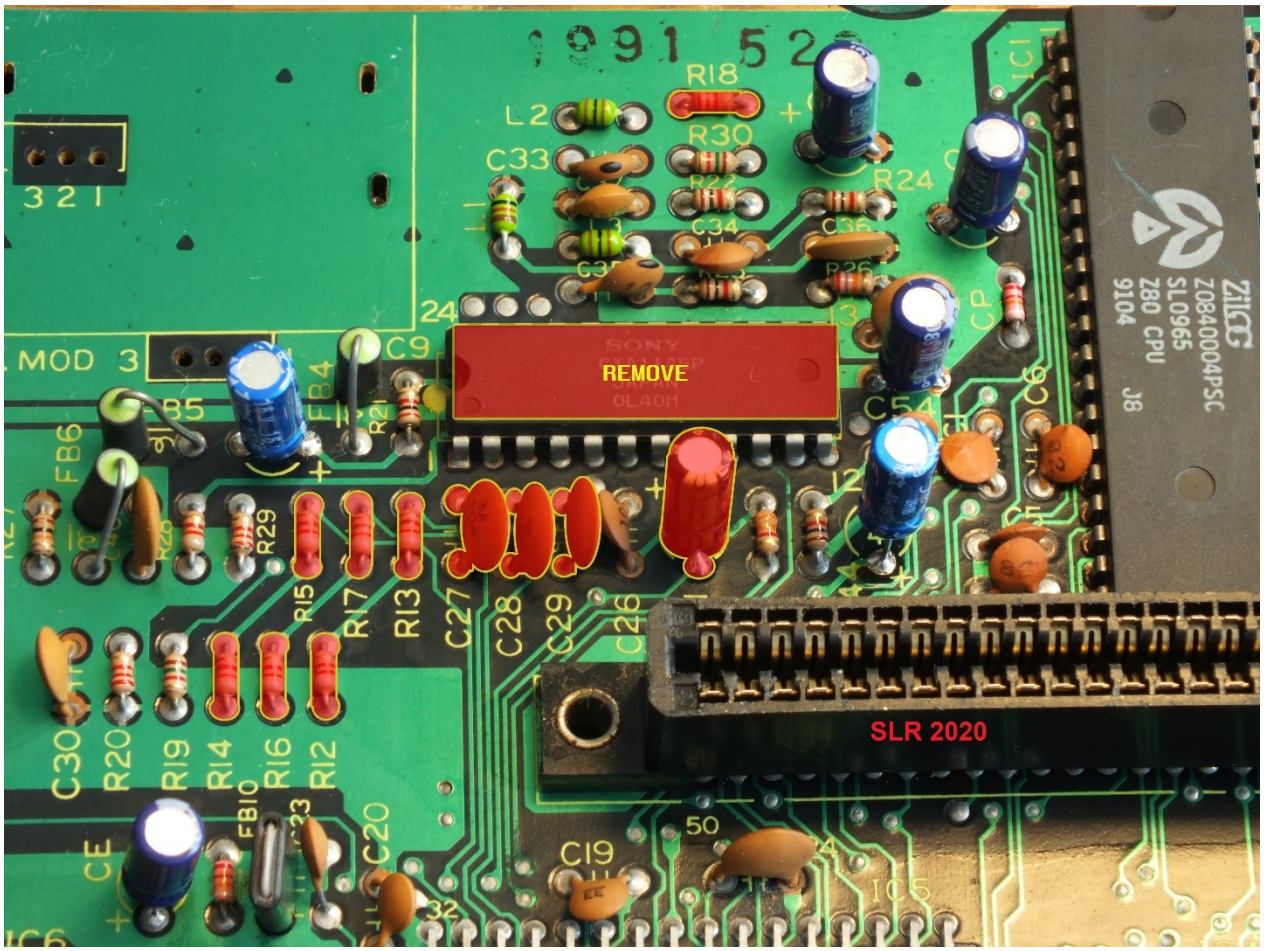
Step 3 – Preparing the mainboard for RGB mods

Remove all the components highlighted in red in the following pictures (choose the relevant board revision). NOTE: this version of the guide has default video encoder (CXA1145 or MB3514) highlighted, but removal of that IC is entirely optional. It is highlighted merely for the sake of being thorough!

NOTE: Many of the components recommended for removal, such as resistors, will have "clinched" leads on the solder joints. If you de-solder using vacuum tip, be sure to un-clinch them first. This can often be done with the vacuum tip itself, or with a solder iron and a pair of tweezers. Be very careful doing this!

For **components like resistors and capacitors**, you can clip them out using side cutters if you don't want to use a vacuum. DO NOT, however, use a cheap "bulb" or mechanical de-solder pump. Anything mechanical is likely not ESD safe.

- Master System 2. Revision IC BD M4Jr. PAL (Alex Kidd model). The highlighted components should ONLY be removed if performing the RGB bypass mod. If doing RGB without bypass, leave these components intact!



The components highlighted above should ONLY be removed if performing the RGB bypass mod. If doing RGB without bypass, leave these components intact!

NOTE: Removal of the CXA1145 IC is OPTIONAL. If you wish to use the buffered audio from CXA1145 (pin 9 is audio output. Input is pin 8), then do not remove the CXA1145 IC, and do not remove C31. However, if you remove CXA1145 and C31 you can get audio via 10uF series capacitor soldered to pin 15 of the VDP.

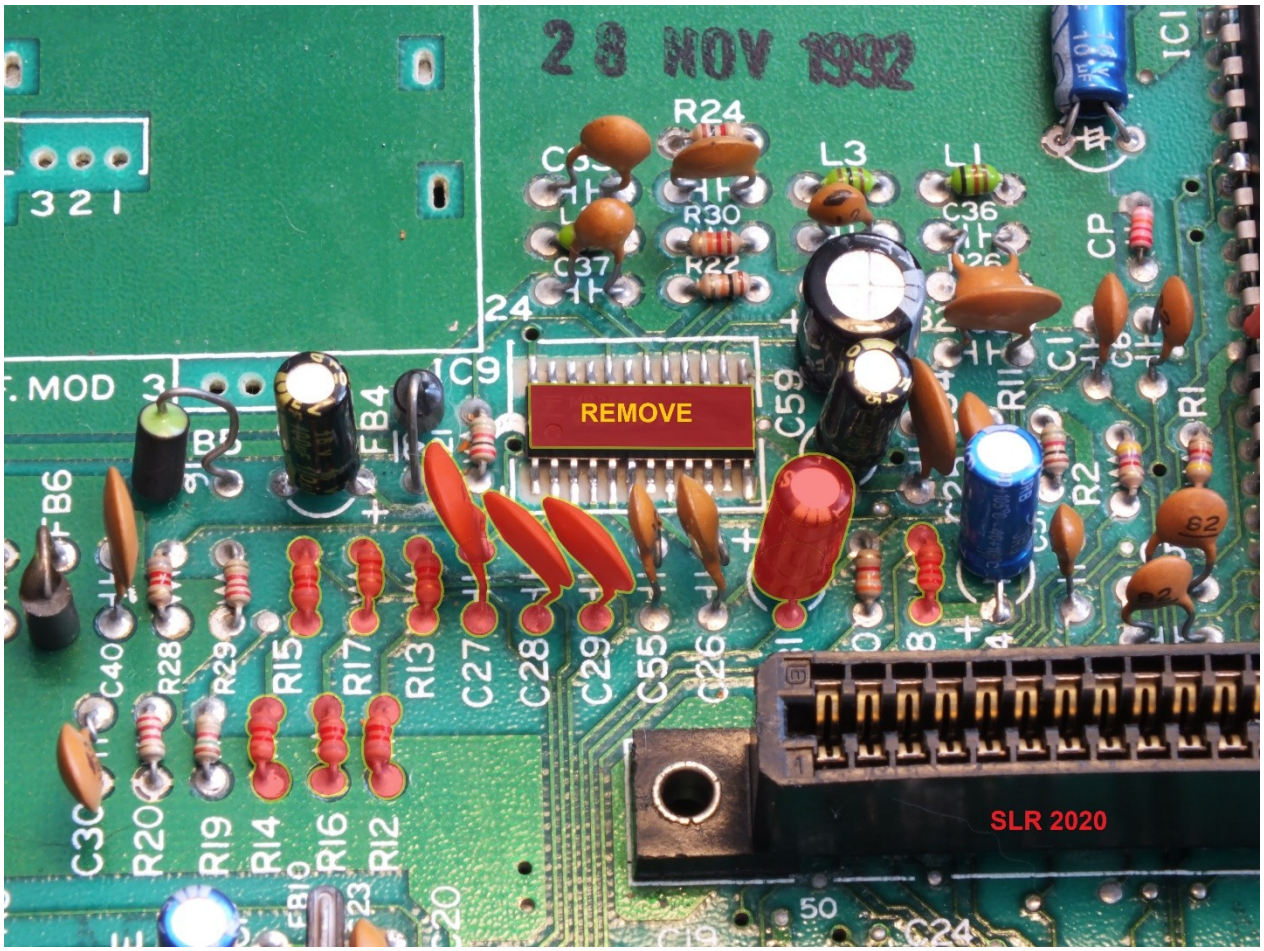
NOTE: If doing SMSFM audio expansion modboard install (from Tim Worthington), you ALWAYS remove C31. The side connected to VDP goes into the SMSFM board and the output from that board goes to your DIN plug for audio through the SCART cable.

- Master System 2. Revision IC BD M4Jr. PAL 2M (Sonic1 model)

This particular revision can achieve a jailbar-free picture without the need for an RGB bypass (though you can still do the RGB bypass if you want), a simple RGB mod would yield similar results.

1. The RGB bypass way :

   The highlighted components should ONLY be removed if performing the RGB bypass mod. If doing RGB without bypass, leave these components intact!



The components highlighted above should ONLY be removed if performing the RGB bypass mod. If doing RGB without bypass, leave these components intact!

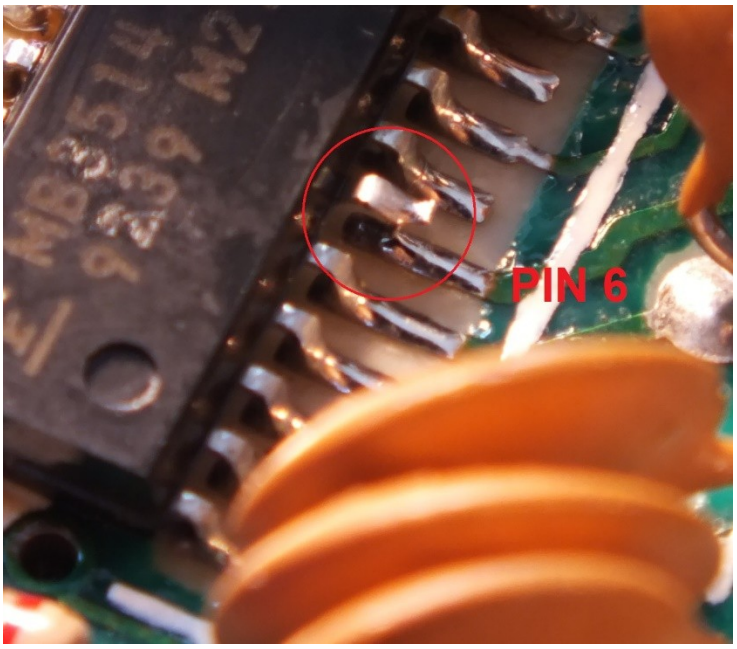
NOTE: Removal of the MB3514 IC is OPTIONAL. If you wish to use the buffered audio from MB3514 (pin 9 is audio output. Input is pin 8), then do not remove the MB3514 IC, and do not remove C31. However, if you remove MB3514 and C31 you can get audio via 10uF series capacitor soldered to pin 15 of the VDP.

NOTE: If doing SMSFM audio expansion modboard install (from Tim Worthington), you ALWAYS remove C31. The side connected to VDP goes into the SMSFM board and the output from that board goes to your DIN plug for audio through the SCART cable.

2. The normal RGB mod without bypass :

Lift pin 6 (subcarrier) of the Fujitsu MB3514 chip (IC 9). ALTERNATIVELY, cut pin 42 and 44 of the 315-5237 IC! This disables the colorburst/subcarrier clock, which is a source of noise. This clock signal is NOT required on RGB!

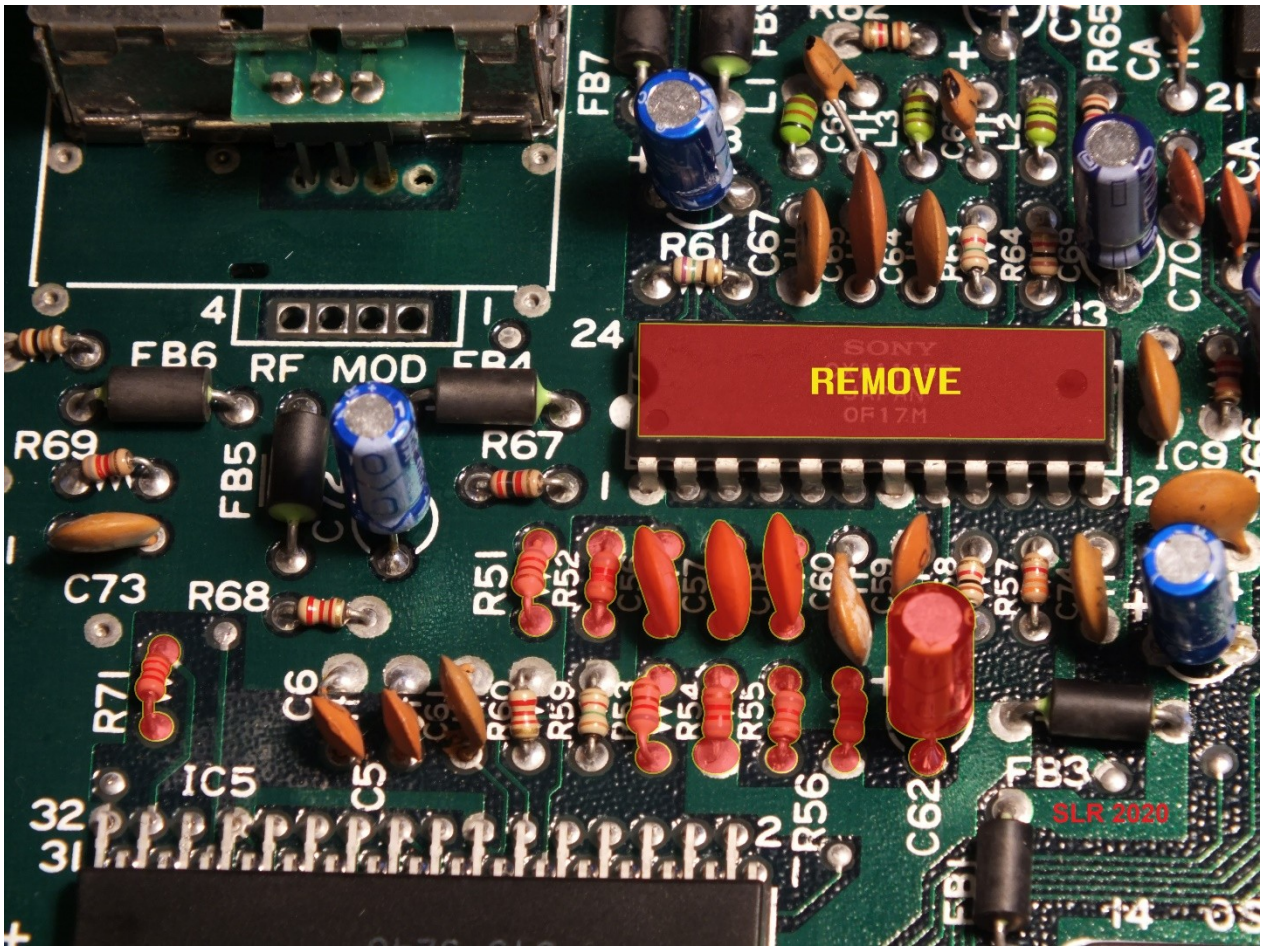
You might also want to put power filter capacitors 4.7uF, 100nF and 470nF each on R12, R14 and R16. These are the main pull-up resistors used on the RGB lines going into the MB3514. This can help reduce any noise on those lines.



Beginner tips: Heat up the pad and use a precision tool such as tweezers or blunted craft knife to carefully lift the pin. This pin carries the subcarrier signal and can cause noise on the RGB circuitry. The issue is more prevalent with 3.58MHz subcarrier on NTSC consoles but should be lifted on PAL consoles as well even though the human perceived benefit will be lesser (due to differences in how these frequencies appear as noise in the signal). Lifting this pin will disable the subcarrier, resulting in black and white picture on composite video or svideo.. Alternatively, this pin could simply be cut, using side cutters, but this is BAD because it can damage the pad (what if you wanted to use the subcarrier in future? For instance, if you decided one day that you want composite video)

- Master System 1. Revision VA-3

  First method shown below is if doing RGB bypass:



The parts highlighted above should only be removed if doing an RGB bypass.

NOTE: Removal of the CXA1145 IC is OPTIONAL. If you wish to use the buffered audio from MB3514 (pin 9 is audio output. Input is pin 8), then do not remove the MB3514 IC, and do not remove C62. However, if you remove MB3514 and C62 you can get audio via 10uF series capacitor soldered to pin 15 of the VDP.

NOTE: Removal of CXA1145 should NOT be done if not doing RGB bypass. If using stock RGB circuit, just do the jailbar fix. SMS1 already outputs RGB and TTL sync to the DIN plug, which is present by default.

NOTE: If doing SMSFM audio expansion modboard install (from Tim Worthington), you ALWAYS remove C62. The side connected to VDP goes into the SMSFM board and the output from that board goes to your DIN plug for audio through the SCART cable.

Beginner tips: Don't bother removing the CXA1145/MB3514. It's simply not required! However, if doing RGB bypass, you'll want to disable the RGB signal path from VDP to video encoder.

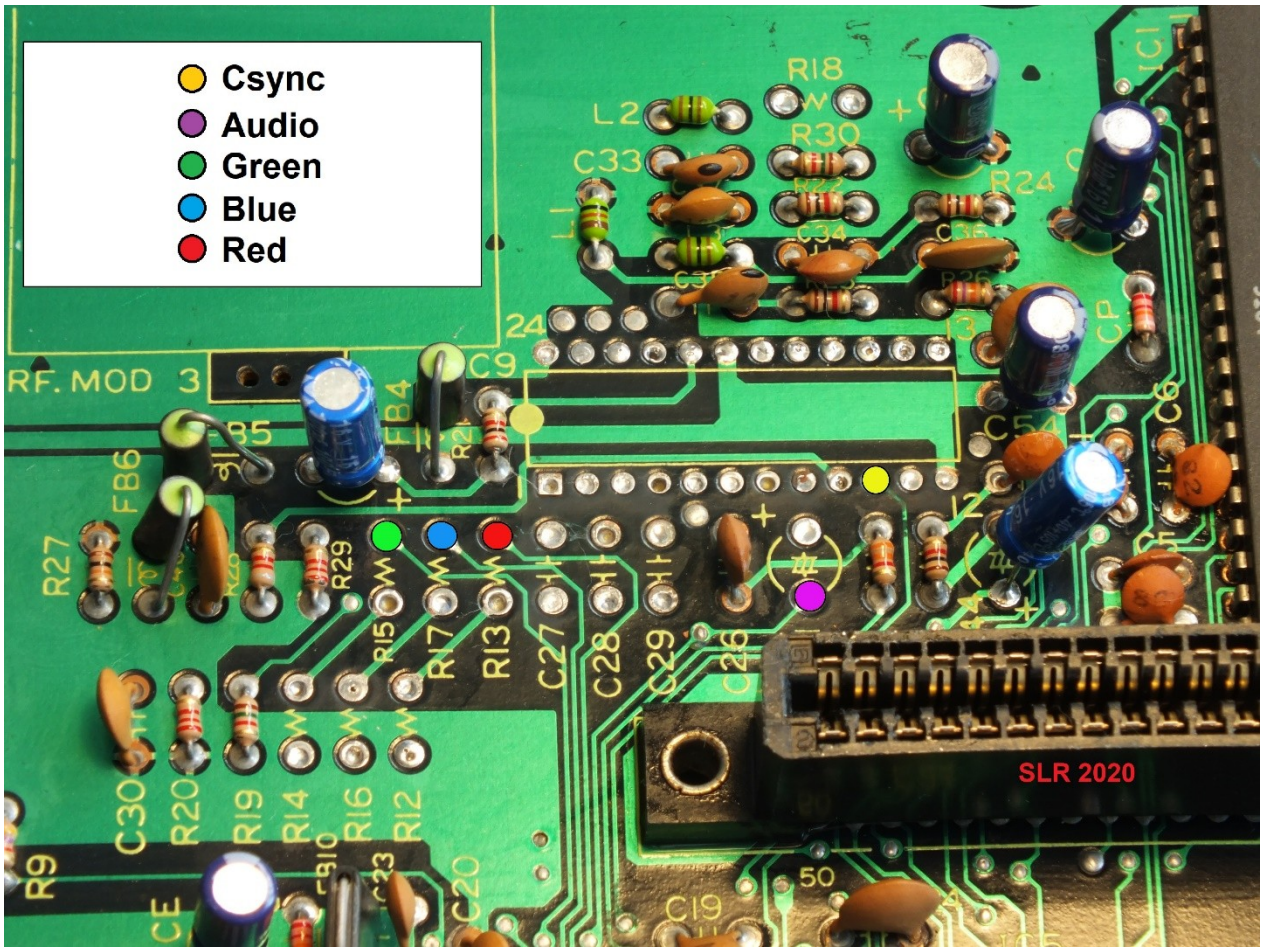
https://www.youtube.com/watch?v=e8KRPFOD1RE shows a good technique to de-solder a through-hole mounted IC such as CXA1145 or through-hole components like resistors or capacitors.

Step 4 – Wiring the RGB Bypass

Refer to these pictures to know where to source Red, Green, Blue, Csync and Audio from (choose the relevant board revision).

- **Master System 2. Revision IC BD M4Jr. PAL**

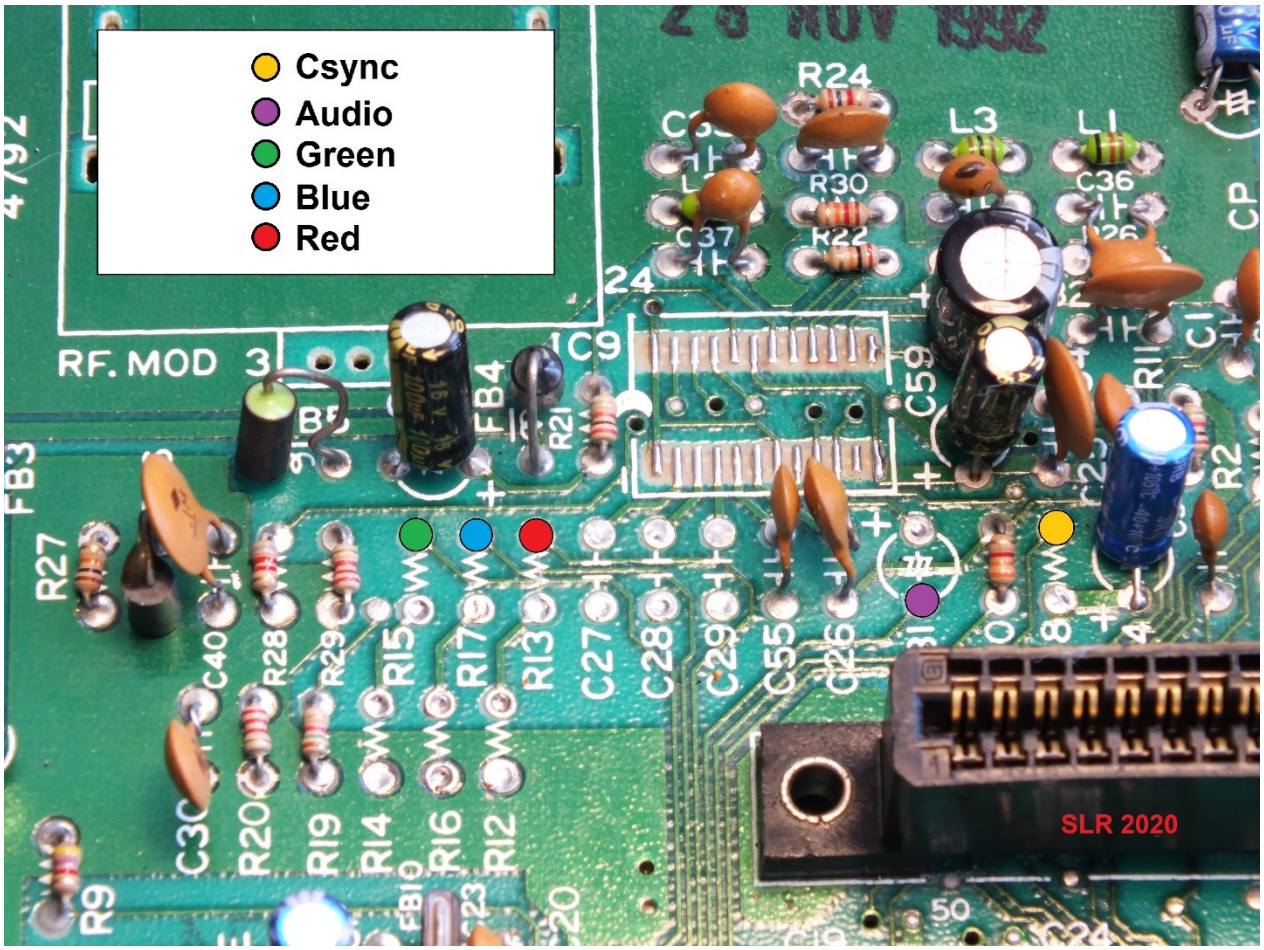
  Connections for RGB bypass, when necessary components are removed:



Wire each point to the corresponding pad on your RGB bypass board.

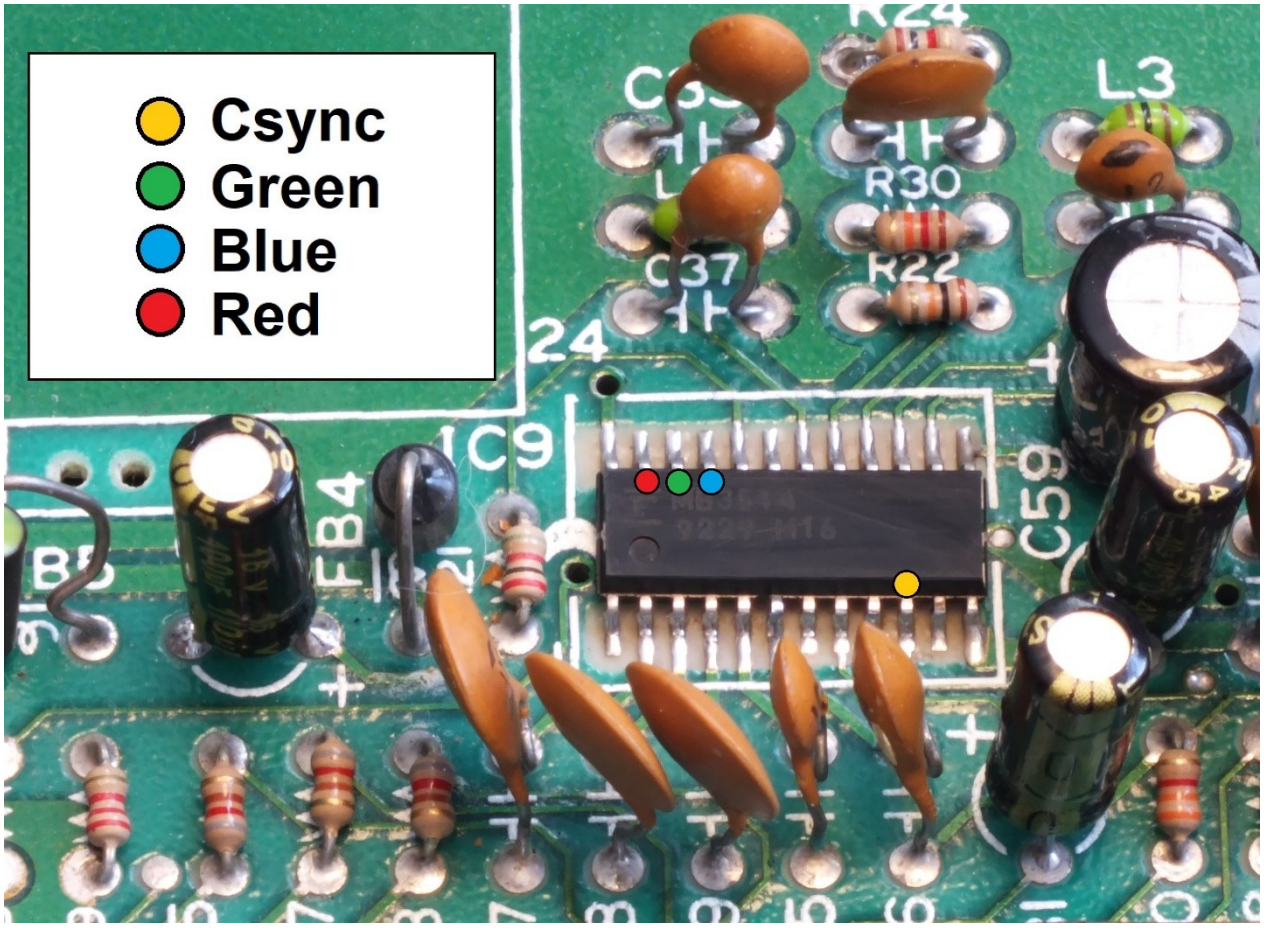
- **Master System 2. Revision IC BD M4Jr. PAL 2M**

1. Connections for RGB bypass, when necessary components are removed:



Wire each point to the corresponding pad on your RGB bypass board.

2. For regular RGB mod without bypass (on Sonic1 SMS2), simple hook up some wires from these points to your DIN plug (CSYNC is TTL level. Use 470ohm resistor and 220uF cap in your SCART cable) :

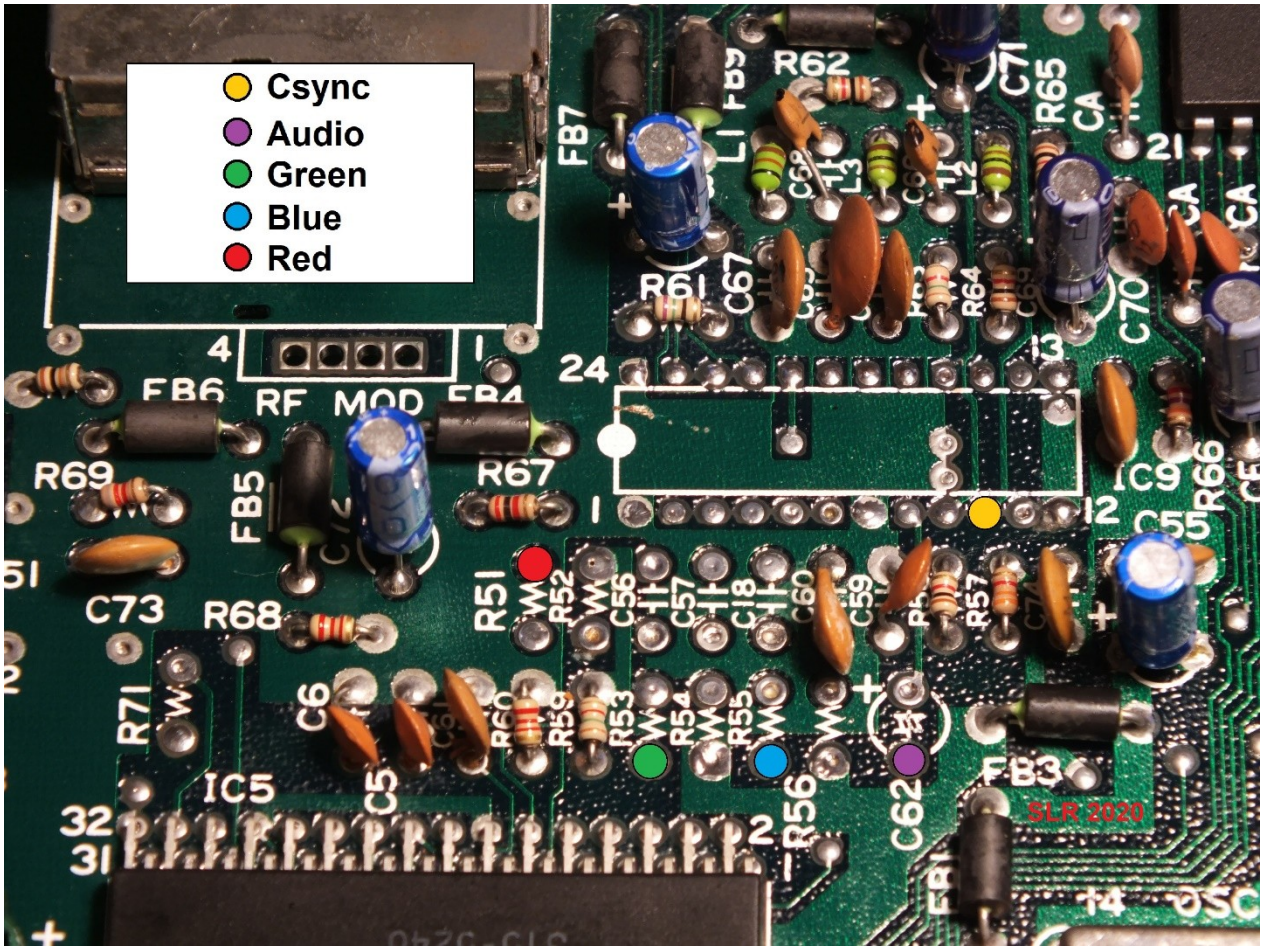


Wire each point directly to your desired AV connector. Check what components are used in your SCART cable. Here are the components needed between the video amp (IC 9) and the SCART head :

Red	75Ω resistor and a 220µF 16V capacitor
Green	75Ω resistor and a 220µF 16V capacitor
Blue	75Ω resistor and a 220µF 16V capacitor
Csync	470Ω resistor and a 220µF 16V capacitor
Audio	10µF 16V capacitor

If components are missing, add them in, either in the SCART head or in the console.

- Master System 1. Revision VA3



Wire each point to the corresponding pad on your RGB bypass board.

A note about audio (all models):

Audio can be taken from pin 15 of the VDP (IC 5), add a 10µF 16V capacitor. Alternatively, leave C31 (on SMS2) or C62 (on VA3 SMS1) in place and hook up audio (without capacitor) from pin 9 of the default video encoder.

we recommend putting the 10uF audio capacitor **inside** the console

The audio line will need to be connected directly to the AV connector of your choice and filtered with a 10µF 16V capacitor (provided your bypass board doesn't have an Audio pad integrated – if it's the case and a capacitor is already present on the audio line, you won't need to add a capacitor and you will simply need to run a wire from the purple point to the Audio pad of the bypass board).

NOTE: 10uF is the standard for the full range on analog audio, though 4.7uF is the "minimum" in most cases. We recommend 10uF, no more no less! BE AWARE: If you use an external amplifier circuit, make sure that IT does not use 10uF in series because 10uF+10uF in series results in a total capacitance of 5uF, due to how capacitors stack in series.

Csync will need to be attenuated and filtered when coming out of the bypass board with a ?ohm* resistor and a 220µF 16V capacitor (provided that they aren't already included in your bypass board, in which case, you wouldn't need to add them in)

*Exact resistor value for CSYNC depends. If using pin 11 (csync output) of CXA1145, use 75ohm resistor. If using pin 10 of CXA1145/MB3514 with default 2.2k pull-up on the line, it's TTL level and you use 470ohm in your SCART cable. We recommend using TTL sync on pin/pad 10 for the video encoder, instead of using any CSYNC circuit present on your bypass board… however, if your bypass board is wired for 75ohm sync, you could bridge TTL sync to the CSYNC input on your bypass board and use your bypass board's sync output via 75ohm resistor and 220uF capacitor to the separate DIN8 pin for composite video. With this, TTL sync and attenuated 75ohm sync will both be available on your DIN8 plug, ensuring compatibility with most MegaDrive/SMS1 cables that get sync on composite video pin (VERY few of them get sync from the TTL sync pin).

A note about 5v and GND locations for DIN plug:

+5V and GND can be taken from a number of places on the board.

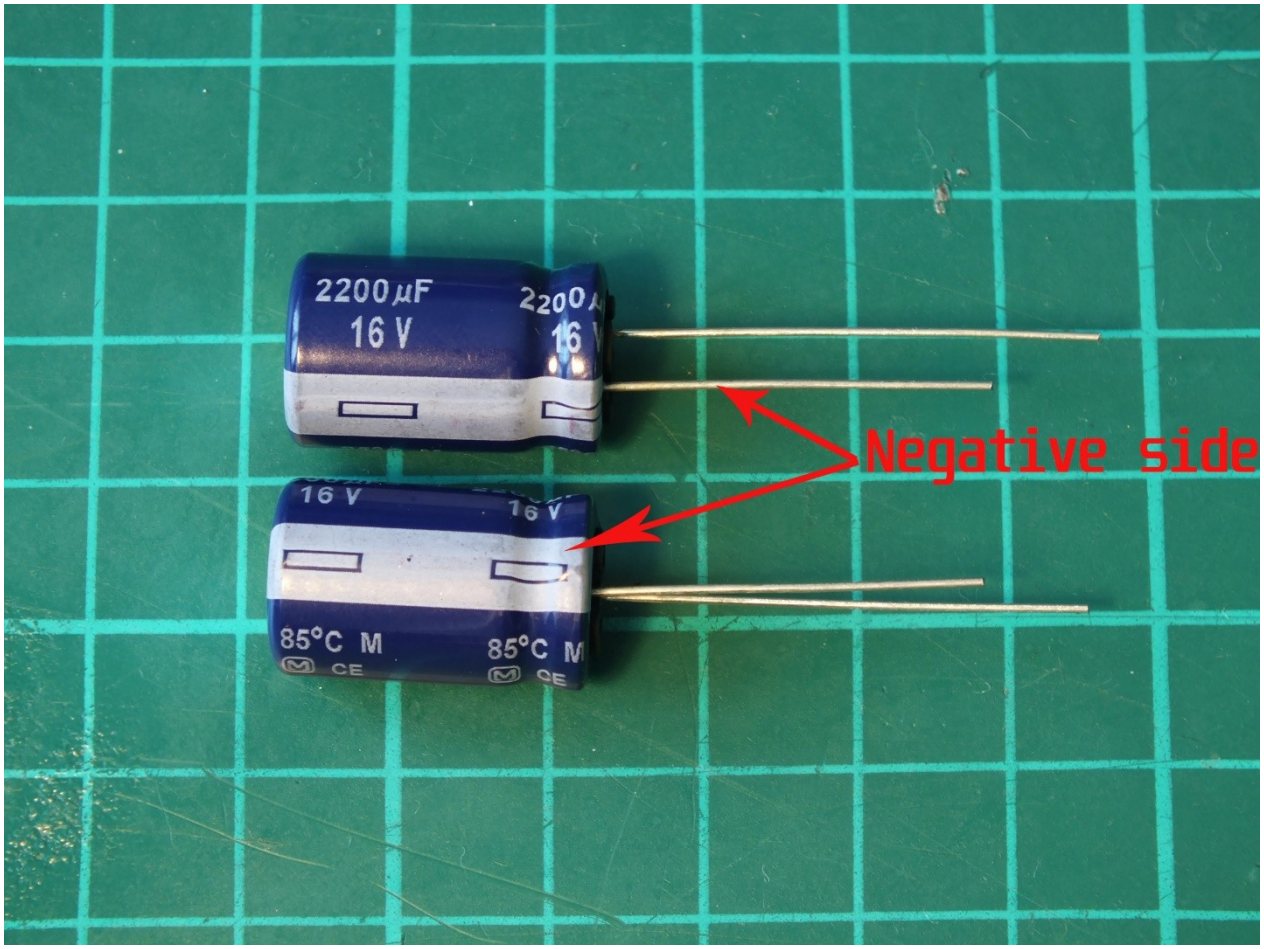
- The BEST place to grab 5V is from the anode (+ side) on C42 on SMS2 (unknown which this is on SMS2). This is the main power filter capacitor coming off of the 5v output of the main voltage regulator. (we're unsure which it is for VA3 SMS1, but you can find it near the 7805)
- A lot of people say to use 5v direct from the 7805 voltage regulator, but this is incorrect. The main filter capacitor coming off of it is the best place, because this is where noise is filtered.

  ALL SCART cables for RGB require a 5v line going through it, with a 180ohm blanking resistor on the line.

  Look up online how the MegaDrive1 DIN plug is wired. Replicate that when modding your SMS2. SMS1 will already have that wiring (unless you change it).

Beginner tips: When running a +5V and GND wires together, the best practice is to twist the pair of wires together, it will cancel the electromagnetic field generated and reduce audio and video noise.

The negative side of capacitor can be identified in two ways, the shorter leg (not useful if the capacitor is already soldered) and the stripe on the side of the capacitor.



Keep your wires as short as possible. Wires are made of copper, long wires become literal antennas and will pick up all kinds of interference.

Step 5 – Cable setup

DIN8 plug should output roughly 1.5v p-p RGB signals (measured on oscilloscope, this is what the default CXA1145 video encoder will do); the 75ohm resistor in the SCART cable, coupled with the 75ohm termination to ground per each video line in your TV, brings this down to about 0.75v or 750mV (it'll be a little bit lower in practise); within tolerance, video line is about 640-780mV with 710 being the ideal value. Then in your SCART cable, you will have 75ohm+220uF in series for RGB lines.

DIN8 plug should output TTL sync and (optionally) attenuated 75ohm sync (grab composite video from default video encoder, for the composite video pin, but use a Sync Stripper IC (LM1881) Attenuate through 75ohm resistor and filter through 220uF capacitor.

NOTE: you can buy fully shielded SMS1 RGB SCART cables on **RetroGamingCables.co.uk** and they will work with the setup described above. You can also tell them which type of sync signal you're using. If your cable already grabs and attenuates TTL sync from the proper pin, then don't bother routing attenuated 75ohm Sync to your DIN8 plug.

If "75 ohm level" and "attenuated 75ohm sync" and "TTL sync" and "attenuated TTL sync" confuse you… go read **retrorgb.com** and it has info about Sync stuff.

Step 6 (only applicable if using Voultar THS7374 RGB bypass board for MegaDrive / Genesis consoles)

The inline RGB resistors and RGB pull-down resistors must be adjusted: inline changed to 75ohm and pull-downs about 1.8k to 2.2k ohms. Make sure that the RGB outputs on DIN are about 1.5mV point to point as measured on an oscilloscope, before reaching the 75ohm resistors and 220uF capacitors in your SCART cable; 75ohm series resistor, plus the 75ohm termination in your TV, will bring the voltage inside your TV to just under 750mV, which is within tolerance (this is why you put 75ohm resistor in the SCART cable). CSYNC output should be at TTL level (5v on or off) and, when attenuated through 470ohm resistor and 220uF capacitor inside the SCART cable, should be roughly 520mV point to point (the tolerated voltage range for CSYNC going into TV is about 200-900mV. DO NOT deviate from this tolerated range!). This is to say, CSYNC should be roughly 520mV point to point when it goes into the TV or upscaler such as OSSC.

NOTE: measuring analog voltages on a multi-meter will not work. You need to measure them on an oscilloscope. However, the resistor values recommended above are roughly correct. The following photo shows these resistors:

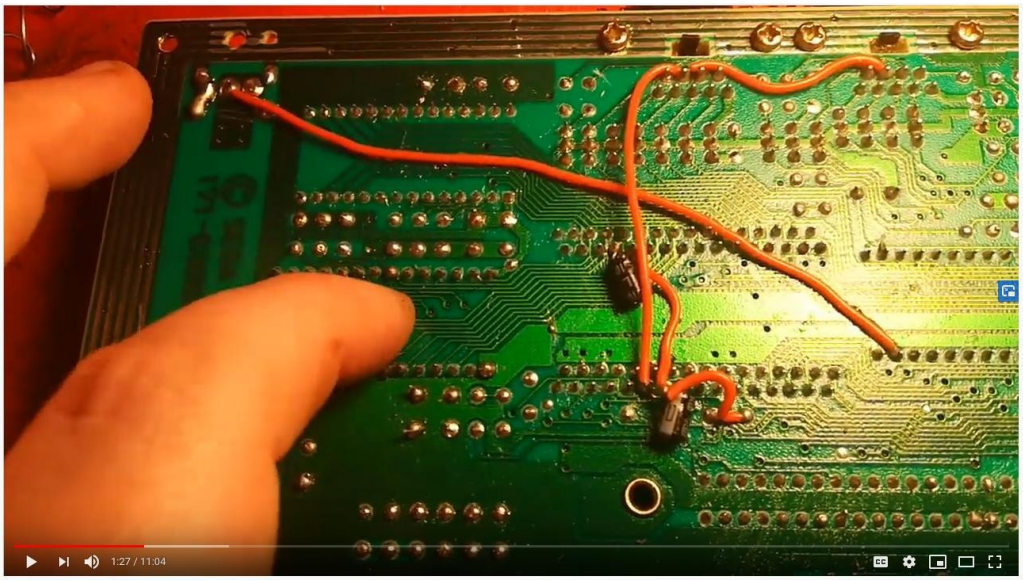
NOTE: If using bypass board, pull-up resistors, inline resistors and capacitors for RGB and sync lines on the SMS mainboard **must** be removed. This was already covered in an earlier part of this document.

In the picture, note that there is a 2.2k pull-up resistor on the CSYNC input. Older versions of the voultar board lack this resistor; add it, if you have one of those older versions.

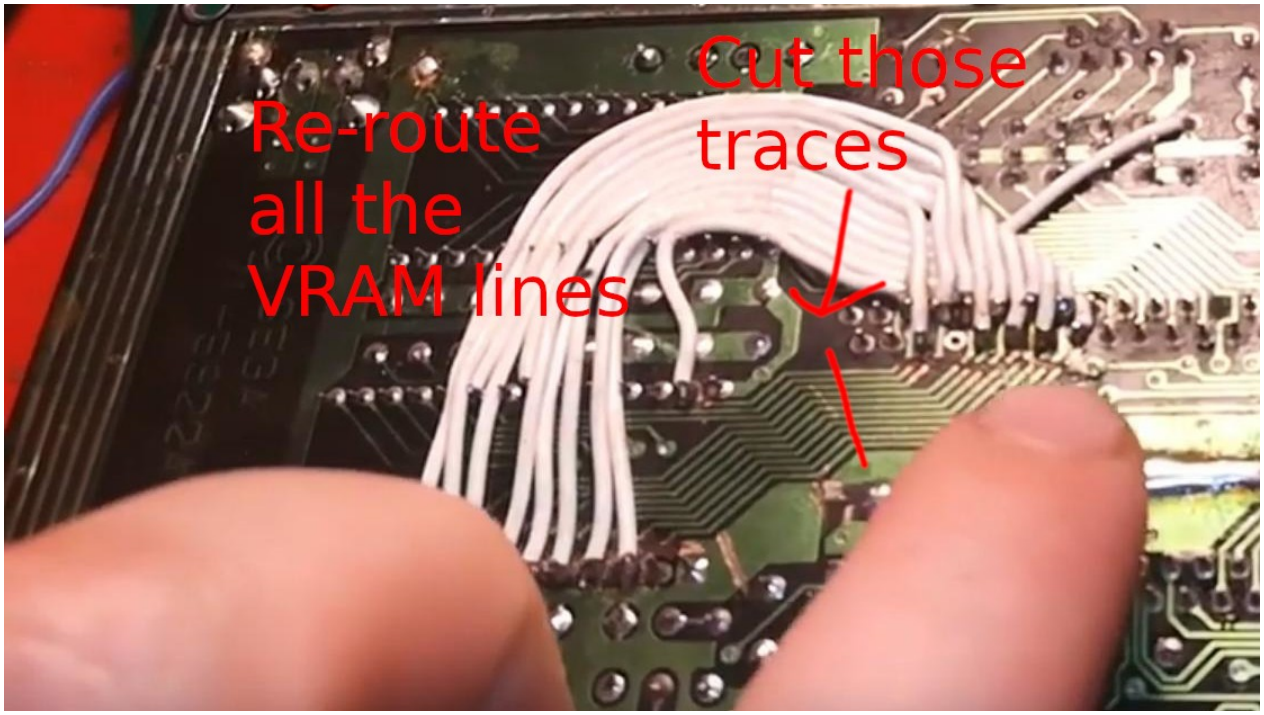
NOTE: This bypass board is not required on Sonic1 SMS2s which use the Fujitsu MB3514 video encoder. On these, we (Leah and Jerome, authors of this guide) have not noticed a difference in quality. On these consoles, a simple RGB mod with TTL sync from MB3514 pin 10 is sufficient.

OPTIONAL STEPS :

4.7uF, 100nF and 470nF filter capacitors on VDP's 5V pins (from 5v pin to ground point. Use ceramic caps). While optional, it's RECOMMENDED. Pin 18 and pin 40 on VDP (315-5346 IC). + side of each cap on 5v pin. - side of each cap going to ground. This filters out noise (especially from RAM/VRAM) on the VDP, and can result in a cleaner analog RGB signal, though it has to do with other types of noise as opposed to jailbars..... look at the example photo:



Re-route VRAM signals (by default they run under the VDP. Run them around the VDP instead. VRAM lines cause noise, on ANY system):



Misc notes:

I, Leah Rowe, initially experimented with isolating all 5V sources to the VDP/encoder IC's and wiring in a 2nd LM7805 voltage regulator (ground on 7805 hard-soldered to SMS2's main ground ring via large solder pool, instead of being mounted to a heat sink) just for the VDP and video encoder, similar to what the MegaDrive 1 does (2 voltage regulators; 1 for digital stuff, and 1 for analog stuff) but this made little difference to picture quality. However, you might want to do this just for shits and/or giggles. It certainly cannot hurt! 100NF power filtering on both 9v and 5v pins of 7805, with additional 100uF filter cap on 5v output... piggyback 9v off of the original 7805 that came with your SMS2.

Conclusion :

Jailbars should now be almost invisible. A 9MHz LPF will mitigate remaining noise. Of course, all of this requires you to use high quality, fully shielded, cables and an interference-free setup (no sketchy SCART switcher etc) alongside decent upscaler such as OSSC, Framemeister or GBScontrol. Enjoy!

NOTE: low-pass filtering IS recommended if using flatscreen/LCD but is not required on CRTs.

NOTE: OSSC uses “sane defaults”, but for best picture, look on YouTube for firebrandx’s video on optimizing the Sega Mega Drive / Genesis to OSSC. He also covers the master system. His H.SampleRate setting might be off by one for real SMS2 and you’ll probably need to adjust the sampling phase.

OSSC has a very decent LPF for Sync and RGB lines. If your bypass board offers the option to enable or disable its own LPF, make sure it’s disabled. Having 2 LPFs is not a good idea and can even cause more noise!

Acknowledgement :

Thank you to **Leah Rowe** for coming up with the idea of bypassing the clock signal of the VDP, simple yet genius. Leah provides professional mod/repair service for many consoles, including Master Systems! Leah is @n4of7 on Twitter and sells pre-modded consoles. You can also send Leah a console you already have, and mod it for you. Website: https://retrofreedom.com/ and https://twitter.com/n4of7

A question? Contact Jerome on Twitter **@SLR_Mod_Shop**

The original guide was by Jerome of Twitter @SLR_Mod_Shop based on Leah’s research.

The guide has been heavily modified by Leah Rowe, over several iterations. Additional info from Leah has been added, and fixes have been made to the original instructions.