HD-64 User Manual

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If you wish to get in touch with the developer, please join the SPL Discord server.

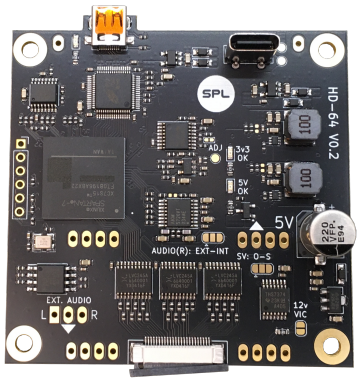

Figure 1. HD-64 (Top)

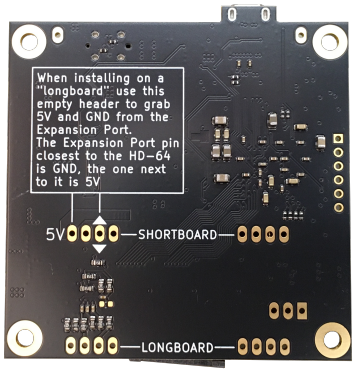

Figure 2. HD-64 (Bottom)

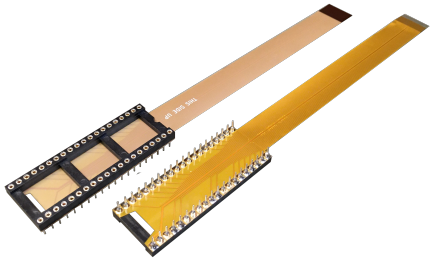

Figure 3. HD-64 VIC-II Interleaver

HD-64 is a replacement for the original RF-Modulator of the Commodore-64 computer, which produces a 1080p HDMI video output, complete with stereo audio. The HD-64 also features a pass-through channel for the analog video, which is still available on the AV connector both in S-Video and Composite format.

> The HD-64 still needs a VIC-II chip (original or replacement) to be present in the computer in order to function.

HD-64 can be purchased pre-assembled from these authorized shops:

- Retro8BitShop
- Retro-Updates

Sales of HD-64 by any shop other than the ones mentioned above may be in violation of the License terms and conditions and should be reported to the developer

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1. Kit Contents

The HD-64 Kit includes the following parts:

1. 1x HD-64 main board (Figure 1)
2. 1x VIC-II Interleaver (Figure 3)
3. 4x 10mm m3 standoffs (with nuts)
4. 2x 4-pin male headers
5. 2x 4-pin female headers
6. 1x flat-pin VIC-II "sacrificial" socket

2. Legend

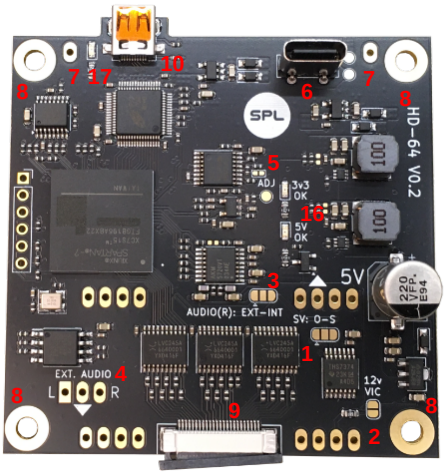

Figure 4. HD-64 Legend (Top)

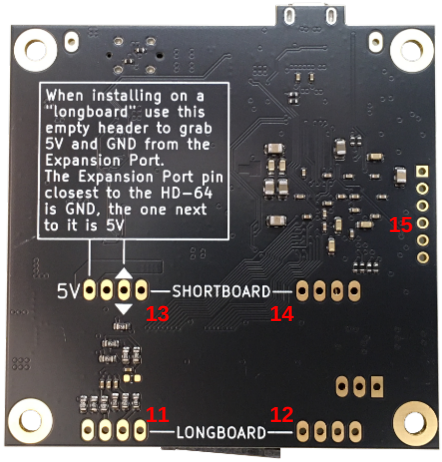

Figure 5. HD-64 Legend (Bottom)

Identifier	Description
1	S-Video Chroma amplitude selection jumper
2	12v VIC-II selection jumper
3	External "right" audio channel selection jumper
4	External audio input header
5	Video PLL Adjustment jumper
6	USB-C firmware update interface
7	Retainer holes (not grounded)
8	Mounting/standoff holes (m3, not grounded)
9	Flat cable connector
10	Micro HDMI connector
11	Longboard motherboard header 1

Identifier	Description
12	Longboard motherboard header 2
13	Shortboard motherboard header 1 / Longboard power input
14	Shortboard motherboard header 2
15	JTAG header
16	Power LEDs
17	Status LED

3. Installation

3.1. Before Installation

- The Original RF-Modulator must be removed and any residual solder needs to be removed from the RF-Modulator header pads on the motherboard
- Always **examine the interleaver** thoroughly. Any pin that receives a trace should have been soldered. Also verify that there are no solder bridges between any two adjacent pins. (Only relevant for the soldered version of the interleaver. The press-fit version has no solder points)
- **Identify your motherboard type.** As far as this installation process is concerned there are only two types of motherboard: the **Shortboard** (model 250469) and the **Longboard** (all other models)

3.2. Differences Between Shortboard and Longboard Installation

- The RF-Modulator headers on Shortboard and Longboard are in different positions and have different pinout. The appropriate pin header to use is clearly marked on the bottom of the board as shown in Figure 2
- The Shortboard provides the necessary supply voltages (5v and GND) directly on the RF-Modulator header on the motherboard. The Longboard does not provide either, therefore when installing the HD-64 on a Longboard requires feeding the supply lines externally (Header 13, Figure 5). The process is explained in more detail in Section 3.3.1

3.3. Installing the HD-64

Installation is best carried out with the motherboard placed and fastened inside the case, so that the HDMI connector can be properly aligned with the case opening.

1. Ensure the computer is powered off
2. Fasten the 4 10mm m3 standoffs to the HD-64
3. Insert the 2 female headers into the motherboard (do not solder them yet)
4. Insert the long side of the 2 male headers into the female headers without pushing them all the way in
5. apply a small amount of "superglue" or a strip of double-sided tape to the bottom of the standoffs
6. Align the HD-64 to the male headers, so that the male headers are inserted from below in the appropriate header pads of the HD-64
7. Carefully align the back of the HD-64 (the side where the HDMI connector is) with the rear edge of the motherboard while making sure the HDMI connector is well centered in the case opening.
8. Push down the HD-64 until the standoffs glue the motherboard. This step will also push the male headers into the female ones.
9. Solder the male headers on the top of the HD-64
10. Without removing the HD-64, solder the female headers on the bottom side of the motherboard

3.3.1. Additional Steps for Longboard Installation

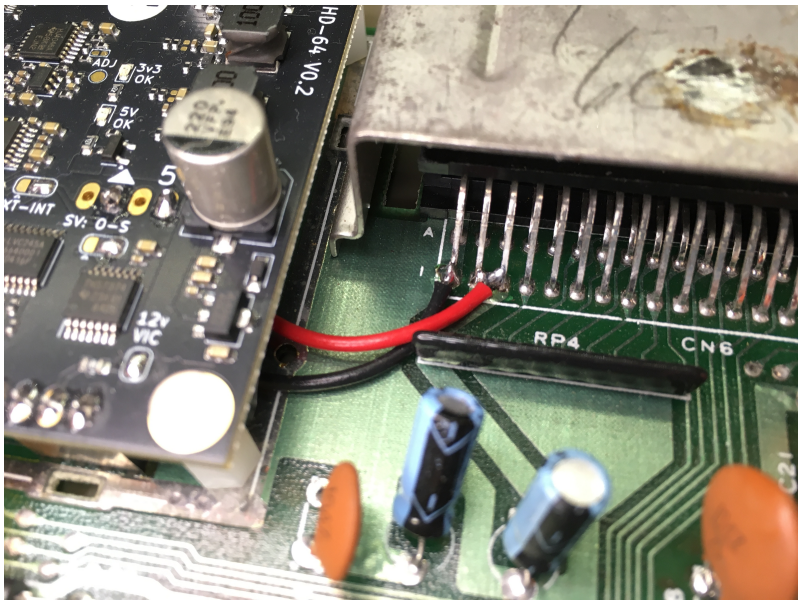

Figure 6. HD-64 Longboard Power Supply

1. Unscrew the standoff nuts and detach the HD-64 from the motherboard
2. Solder two supply wires (AWG 22-24) to the pins marked as "5v" and "ground" (triangle) on Header-13 (Figure 5)
3. Re-install the HD-64 on the motherboard
4. Solder the supply wires to the **expansion port** power supply pins like shown in Figure 6, making sure that:

- the **ground** wire is connected to the expansion port pin **closest** to the HD-64.
- The **5v** wire is soldered the one (or two) pins **next** to the ground wire on the expansion port.

3.4. Power Supply Verification & Fastening

1. Once the steps in Section 3.3 have been carried out and **before** performing any other step, turn on the computer and verify that both power leds are turned on (Item 16 in Figure 4).
2. If the leds do not turn on it is a sign that the supply lines might be inverted or not properly connected. This should only ever happen when installing the HD-64 on a Longboard. If this is the case check again the connection of the supply lines to the expansion port as outlined in Section 3.3.1
3. At this point, verify that you are getting composite video out of the original AV connector. (S-Video is available too but at this point of the installation process it is black & white).

If the computer does not operate correctly (no analog video, weird characters on screen, flickering, glitches…) the installation was not performed correctly. DO NOT PROCEED ANY FURTHER!. Please perform the following steps until the computer outputs proper analog video through the original AV connector:

a. Cross-check all solder points

b. Check for shortcircuit on the top and bottom of the motherboard

c. clean the motherboard with a soft brush

d. attempt replacing key components such as RAM, CPU, VIC-II, PLA…

1. (optional) In order to permanently fasten the HD-64 to the motherboard, drive a long pin or a piece of wire through the retainer pins close to the rear of the HD-64 (Item 7 in Figure 4) and solder one end to the top of the HD-64, and the other end to the exposed ground plane on the motherboard. (It is generally necessary to remove the motherboard from the case to perform this step)

3.5. Installing the VIC-II Interleaver

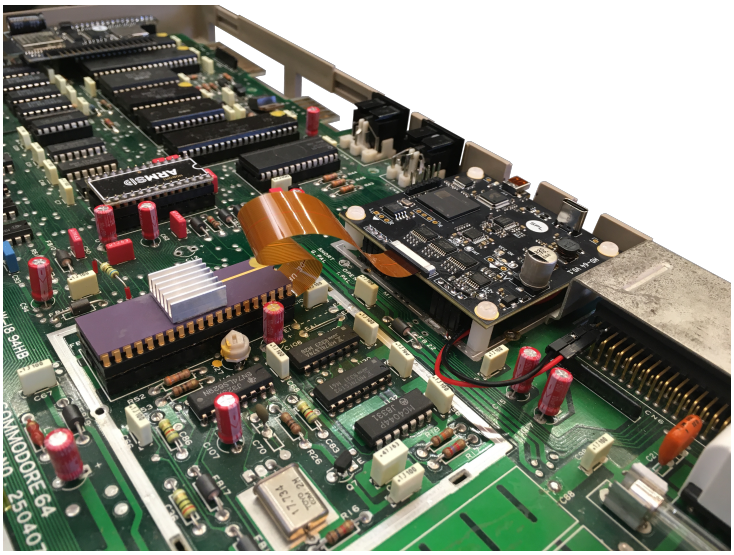

Figure 7. HD-64 Longboard Power Supply

1. Ensure that the computer is powered off
2. Remove the VIC-II from the motherboard
3. Install the VIC-II on the Interleaver socket with the notch towards the flex cable. It is not necessary to push the VIC-II all the way in the Interleaver socket in this step
4. Place the Interleaver socket (with the VIC-II installed on top) on the VIC-II socket on the motherboard and press until both the interleaver is well seated in the motherboard socket and the VIC-II is well seated in the Interleaver socket
5. If the motherboard socket rejects the interleaver, place the additional flat-pin "sacrificial" socket between the motherboard and the Interleaver
6. Connect the flat-cable to the HD-64 **with the dark stiffener on top and the gold contacts on the bottom**.
    - Open the receptacle by pulling out the black tab parallel to the surface of the board
    - Insert the flat cable in the receptacle all the way in, making sure that the cable is perpendicular to the receptacle (use the stiffener as reference)
    - Lock the receptacle by pushing the black tab back in. Some pressure might be necessary for this step

3.6. Final Verification

Once all the steps in Section 3.3, Section 3.4 and Section 3.5 have been performed turn on the computer. The status LED next to the HDMI connector (Item 17 in Figure 4 should turn solid-green. If this does not happen this might indicate that the flat cable is not connected properly.

> When using a Kawari VIC-II replacement make sure to update it to the latest firmware version as older versions are not compatible with the HD-64. In case of problems contact the developer.

4. Jumper Configuration

4.1. Audio Jumper

The jumper denominated "AUDIO ® EXT-INT" (Item 3 in Figure 4) controls whether the right audio channel receives the signal coming from the motherboard through the RF-Modulator header or the one coming from the "EXT. AUDIO" header (Item 4 in Figure 4). The right audio channel **receives no signal** until one side of the jumper has been closed.

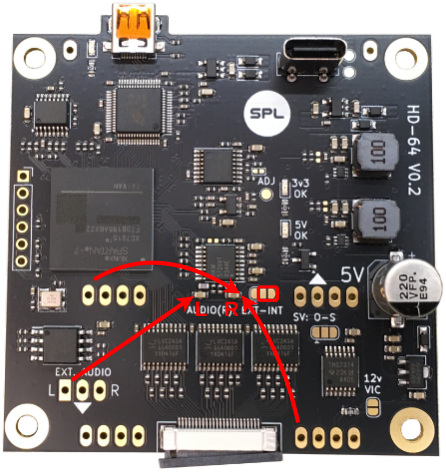

Figure 8. Right Audio Internal

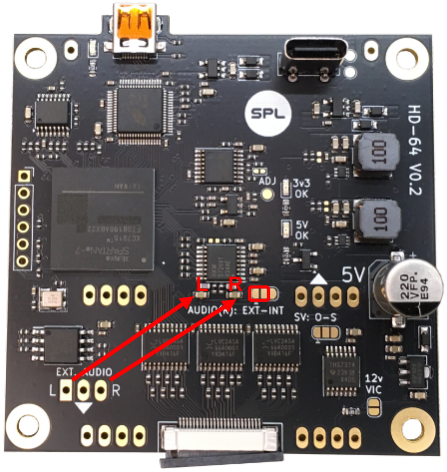

Figure 9. Right Audio External

> Audio can be switched between "stereo" and "mono" via the HD-64 configuration utility as described in Section 5. When "mono" audio is selected, the **right channel** is used as audio source.

4.2. Analog Video Jumpers

The jumper denominated "SV: O-S" (Item 1 in Figure 4) determines whether the amplitude of the chroma signal (on the S-Video analog output) matches that of an original RF-Modulator, or if it should have the lower "standard-compliant" amplitude. **No chroma is available** on the S-Video analog output until one side of the jumper has been closed.

The jumper denominated "12v VIC" (Item 2 in Figure 4) should be closed when a 12v VIC-II is being used (VIC-II models 6567 & 6569).

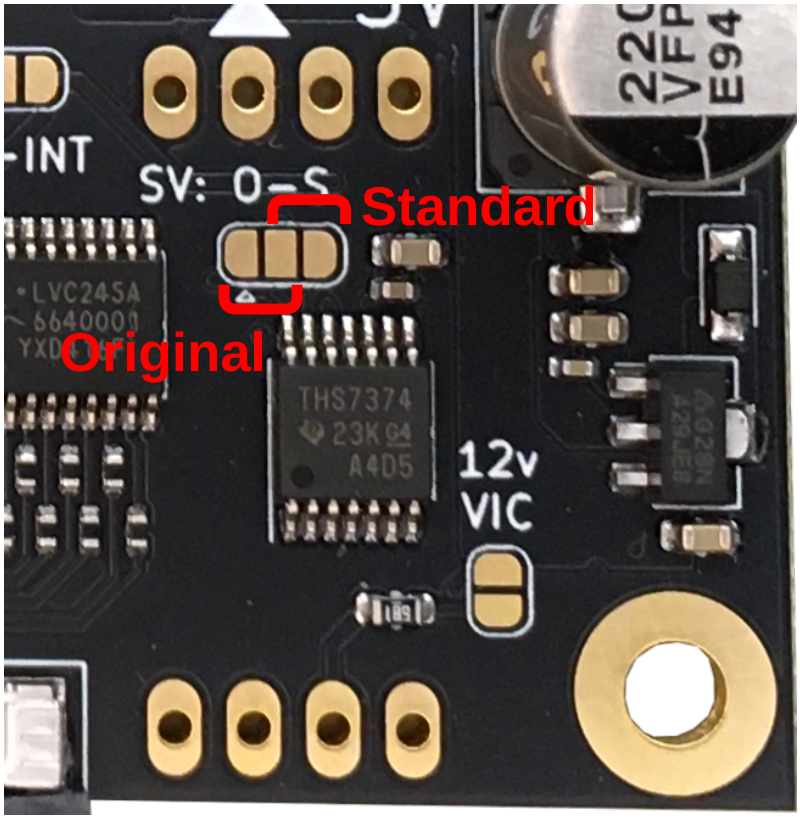

Figure 10. Analog Video Jumpers

4.3. Video PLL Adjustment Jumper

In the unlikely case that the performance of the video synchronization circuit drifts over time, to the point that synchronization is no longer obtained (HDMI video output absent or unstable) it is possible to close the jumper denominated "ADJ" (Item 5 in Figure 4) to bring the synchronization circuit back within the optimal range of operation.

5. Configuration Utility

The various parameters of the HD-64, like color palette, scanlines, blue and wide screen can be configured through the configuration utility (`hd64_cfg_util.prg`) which runs directly on the C64.

The configuration utility is distributed alongside each firmware version on GitHub

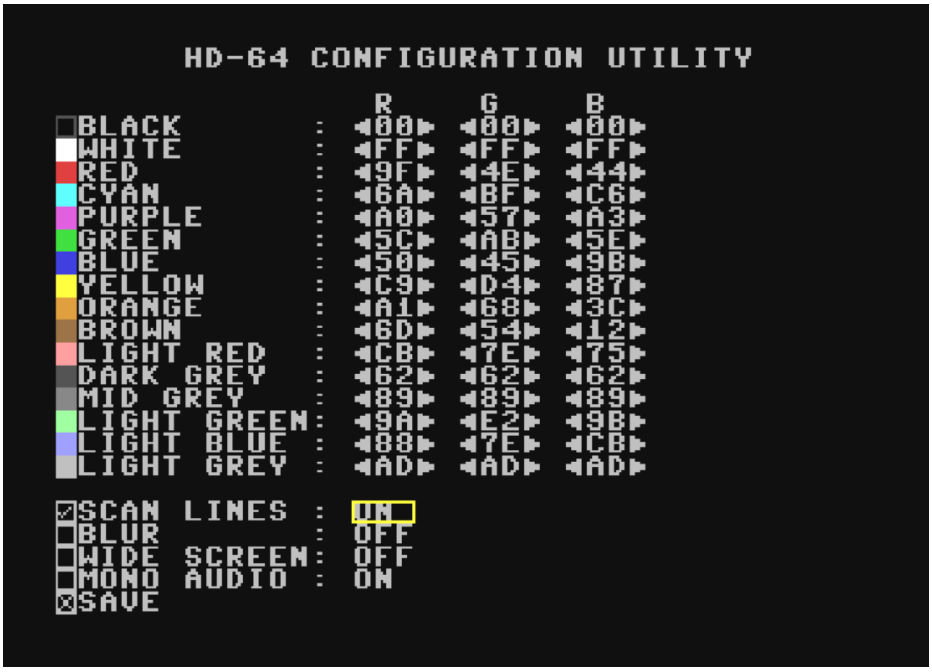

Figure 11. HD-64 Configuration Utility

- The configuration utility is operated with the "ASDW" for moving the cursor and "ENTER" to confirm
- The configuration utility cannot read values from the HD-64, it can only write them. Because of this, values that have not been modified show a **default value** that may not be representative of the real state of the HD-64.
- Once a value is modified in the configuration utility, the new value is written to the HD-64 and from that moment on that parameter is synchronized between the configuration utility and the HD-64 (until the configuration utility is closed).
- In order to save the current configuration, move the cursor to the "SAVE" button and press "ENTER".

  Only the values that have been modified in this session (whith show a tick  mark) will be overwritten in the HD-64.
- The version of the configuration utility always needs to match the firmware version of the HD-64. If the two versions do not match, the configuration utility won't be able to change the parameters of the HD-64.

The configuration utility cannot read the firmware version of the HD-64, so the only feedback for a version mismatch is that changing parameters in the configuration utility has no effect. There are three ways to ensure that the two versions match:

1. Run the Firmware Update executable as described in Section 6. The script displays the current firmware version of the HD-64 and can be interrupted before actually performing the firmware update. Once the HD-64 firmware version is known, download the configuration utility from the appropriate release on GitHub
2. Update the HD-64 firmware to the latest version and utilize the configuration utility distributed alongside the update package
3. Start from the latest available release and try progressively older configuration utility version until you find one that works

6. Firmware Update

The firmware of the HD-64 can be upgraded by connecting it to a PC through the on-board USB-C port (Item 6 in Figure 4).

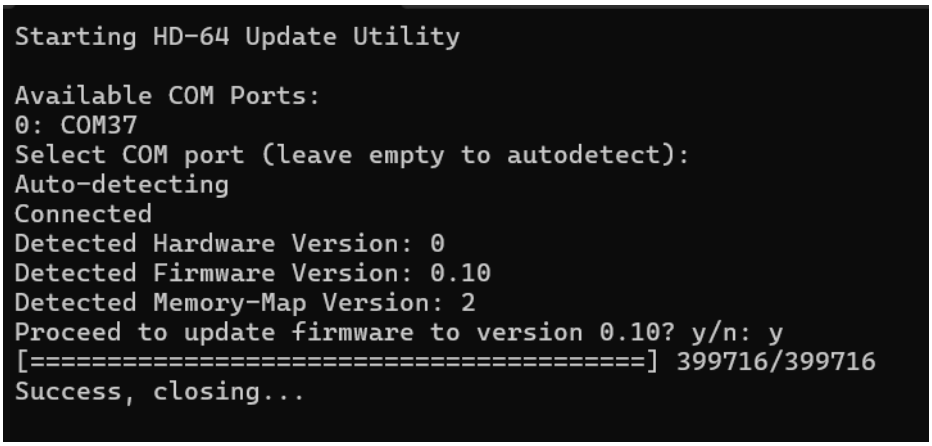

Figure 12. HD-64 Firmware Update Executable

The C64 must be powered on for the whole duration of a firmware update

Due to the fact that the "breadbin" and the "C64-C" hase have holes in different position it was not possible to have the USB-C port accessible on the back of the computer. It is therefore necessary to open the case to update the HD-64.

1. Download and extract the latest firmware update package from GitHub
2. Power on the C64
3. Connect the HD-64 to a PC through the USB-C port
4. Verify that the HD-64 appears as a new COM port under "Device Manager". If this does not happen, install the appropriate FTDI drivers
5. Once the HD-64 has been recognized run the update executable (**firmware_update.exe**)
6. Follow the prompts. When asked to choose the COM port, always try to let the tool "auto-detect" the HD-64 first, and only if that does not work specify the correct COM port manually.
7. Once the firmware update executable succeeds power-cycle the C64.
8. (optional) re-running the firmware update executable will display the current firmware version

A firmware update does not erase the current configuration of the HD-64. In the unlikely scenario that the configuration data is moved in memory across firmware versions it is likely that colors will be "messed up" after the update.

In order to fix this, run the configuration utility as described in Section 5, modify all parameters, then revert them, save the configuration and finally power-cycle the C64.

6.1. Firmware Update Error & Recovery Firmware

Errors might happen during a firmware update procedure. This could be due to program crashes, power outages or other issues. When this happens the firmware update executable will likely crash and not terminate with "Success, closing…" as depicted in Figure 12

> If an error happens during firmware update, first try to repeat the update procedure **without power-cycling the C64**.

If the C64 is power cycled after a firmware update error, more likely than not it will boot in "recovery mode", in which case the status LED (Item 17 in Figure 4) starts blinking. Recovery mode produces no HDMI video output (the analog video output is still available) but does allow new firmware updates. It is thus possible to attempt a firmware update once again as described in Figure 12 to restore the full functionality of the HD-64.

7. Troubleshooting

1. **Constant black screen / "No cable Connected" (HDMI):**
    a. Ensure the monitor supports HDMI 1.4 or later
    b. Ensure that your monitor/TV supports 1920x1080p resolution (FullHD). The HD-64 can only output FullHD video and as such the monitor must support it. Crucially, several old 720p (HD) monitors support 1080i resolution (interlaced), which is also incompatible with the HD-64
    c. see also "Intermittent black screen"
2. **Intermittent black screen (HDMI):**
    a. Measure the voltage on the 5v rail on the HD-64 (right on the board). Anything below 4.8v won't allow the HDMI link to operate correctly. If this is the case please replace the C64 power supply
3. **Weird colors: (HDMI)**:
    a. Ensure the monitor supports HDMI 1.4 or later
    b. If the screen has a green tint (especially in areas that should be black) the output of the HD-64 is set to "RGB" mode but the screen is interpreting it as YCbCr
    c. If the screen has a pink/violet tint (espacially in areas that should be black) the output is set to "YCC" (YCbCr) mode but the screen is interpreting is as RGB.
    d. Use the configuration utility to change the video mode between "RGB", "YCC" and "DVI" until the picture looks correct. DVI mode is expected to always work, with the crucial disadvantage that it does not support audio through HDMI
4. **No Audio (HDMI):**
    a. Check if sound is coming from the AV connector of the C64.
    b. Check that all appropriate audio jumpers are properly closed and there are no cold solders
    c. Try to toggle mono/stereo audio in the configuration utility
    d. Try a different screen to determine if your first display is affected by a known issue described in Section 8.3
5. **Random crashes/freezes**
    a. The HD-64 plugs directly on several sensitive internal lines of the C64. If one or more components

are near the end of their life, the additional parasitic capacitance, though miniscule, can be enough to cause data transfer errors on the memory bus

b. Replace older components until the problem disappears, starting from the RAM and moving on to the PLA, the CPU and possibly others.

8. Known Issues

8.1. Analog Chroma Amplitude Hardware Bug

Due to a component mixup while ordering the first production batch of board version 0.2, resistors R19 and R67 have wrong values, which causes the chroma amplitude to be out of spec.

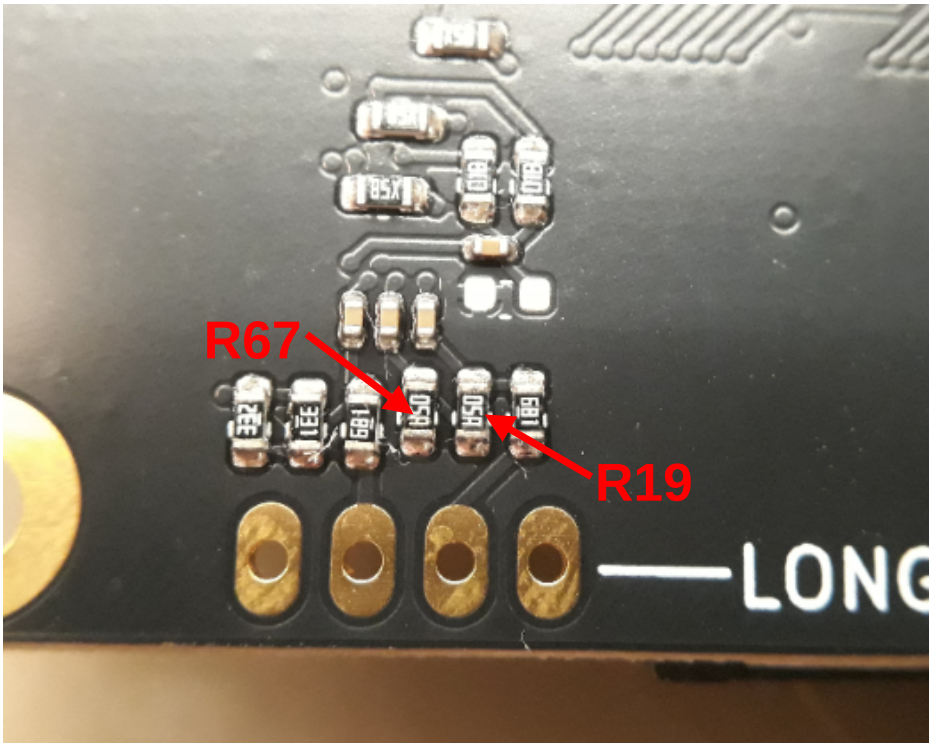

Figure 13. HD-64 Chroma Amplitude Hardware Bug

In the affected boards, both resistors have a value of 110 Ohm (the markings are "05A"), instead os 220 Ohm and 100 Ohm respectively.

Even with this issue it is likely that there will be no noticeable problem on CRTs and LCDs due to the ability of most screens to compensate for inaccuracies of the chroma amplitude. Should the color look "off" there are two recommended ways to fix the issue:

What to do: . Replace R19 and R67 with 220 Ohm and 100 Ohm respectively (0603 size) or, . Add a 680 Ohm 0603 resistor on top of R67 (so without removing the current resistors) so that the parallel of the original 100 Ohm resistor and the added 680 Ohm becomes 87 Ohm, which brings the chroma amplitude back to the correct value.

8.2. HDMI PLL Bias Hardware Bug

Boards of production batch 1 and 2 are affected, though this bug is unlikely to have any real world ripercussions.

Resistor R50 has the wrong value (22kOhm), causing the PLL bias to be lower than originally intended (1.5V instead of 2.1V), though well within the allowed margin (1V to 3V).

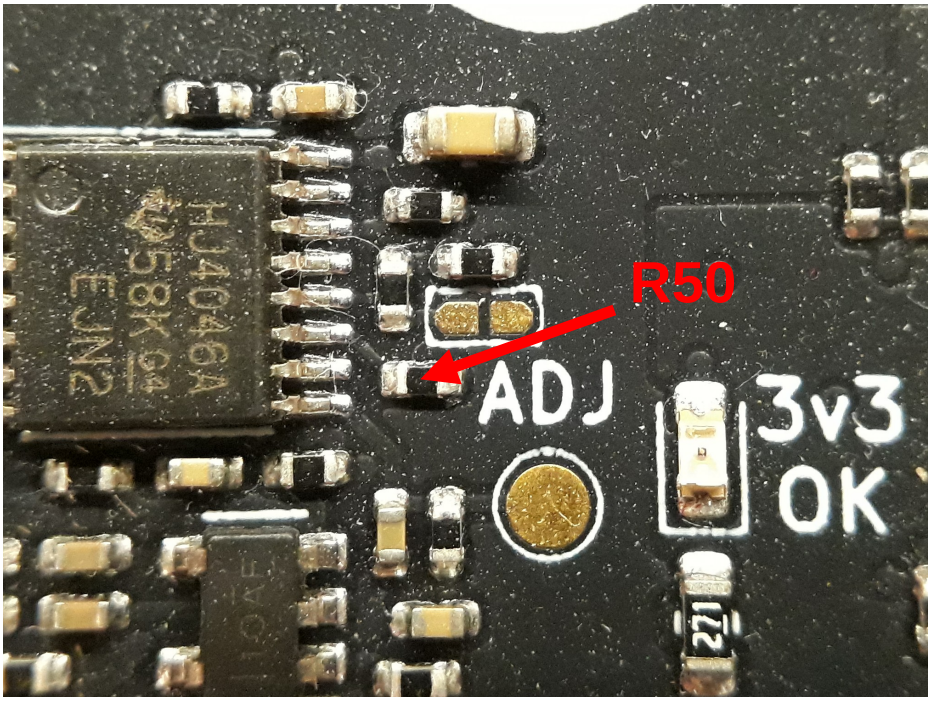

Figure 14. HD-64 PLL Bias Hardware Bug

This imperfection means that the "Adj jumper" (Item 5 in Figure 4) will not be effective against a possible decrease of the PLL center frequency due to component aging. Should the PLL bias voltage spontaneously drift towards or below 1V over time, closing the "Adj jumper" will further lower the bias, causing the PLL to operate even out of specs.

> **What to do:** If the voltage on the test point nearby the "Adj Jumper" falls below 1v (with the Adj jumper open), R50 shall be replaced with a 33kOhm, 0402 resistor.

8.3. Audio Compatibility Issues

TLDR: there is a hardware bug in the EP952 HDMI transmitter used in the HD-64 which causes a very small percentage of displays to not receive audio correctly. Unfortunately this cannot be fixed in software (or not completely)

The long version…

HDMI Sinks (TVs, displays, monitors) must recover the sampling rate of the incoming audio stream in order to play it back. Different sinks will use different techniques to do so. Some of these techniques are "smarter" than others, as in, they rely less on the assumption that the source is 100% compliant to the HDMI standard, which in turn improves overall interoperability, especially in the presence of hardware bugs.

Among the many requirements of the HDMI standard, is that the source must transmit a special ACR (Audio Clock Regeneration) packet at a certain rate. This packet contains information about how the audio clock was generated on the source, so that the sink can replicate it more easily.

While it is not a strict requirement, the best performance in terms of audio quailty is achieved when such packet is transmitted about 1000 times per second (this number is actually based on quite a few factors), with increasing quality degradation the further the actual rate of ACR packets is from this 1kHz target.

The issue with the EP952 is that the chip is hard wired to send the ACR packet only once per frame, so about 50/60 times per second as opposed to the optimal 1000. This leads to two scenarios:

1. Most monitors do not rely on the frequency of ACR packets, but just on their contents in order to recover the audio clock. Such monitors are therefore unaffected.
2. Some monitors **do rely** on the frequency of ACR packets being compliant with the standard in order to recover the audio clock. Such monitors won’t be able to reproduce audio correctly or at all.

Luckily the vast majority of TVs and monitors available today (even on the 2nd hand market) fall in the 1st cathegory. For the 2nd kind, there is unfortunately no reliable solution for now.

What to do: Unfortunately, if you are affected by this issue the only option is to utilize a different, possibly more modern monitor/TV