High Fidelity Digital to Analog Converter & Media Stream Box

Designed By
Kyle Kenyon

Components from:
Ian Canada
Raspberry PI Foundation

Executive Summary:

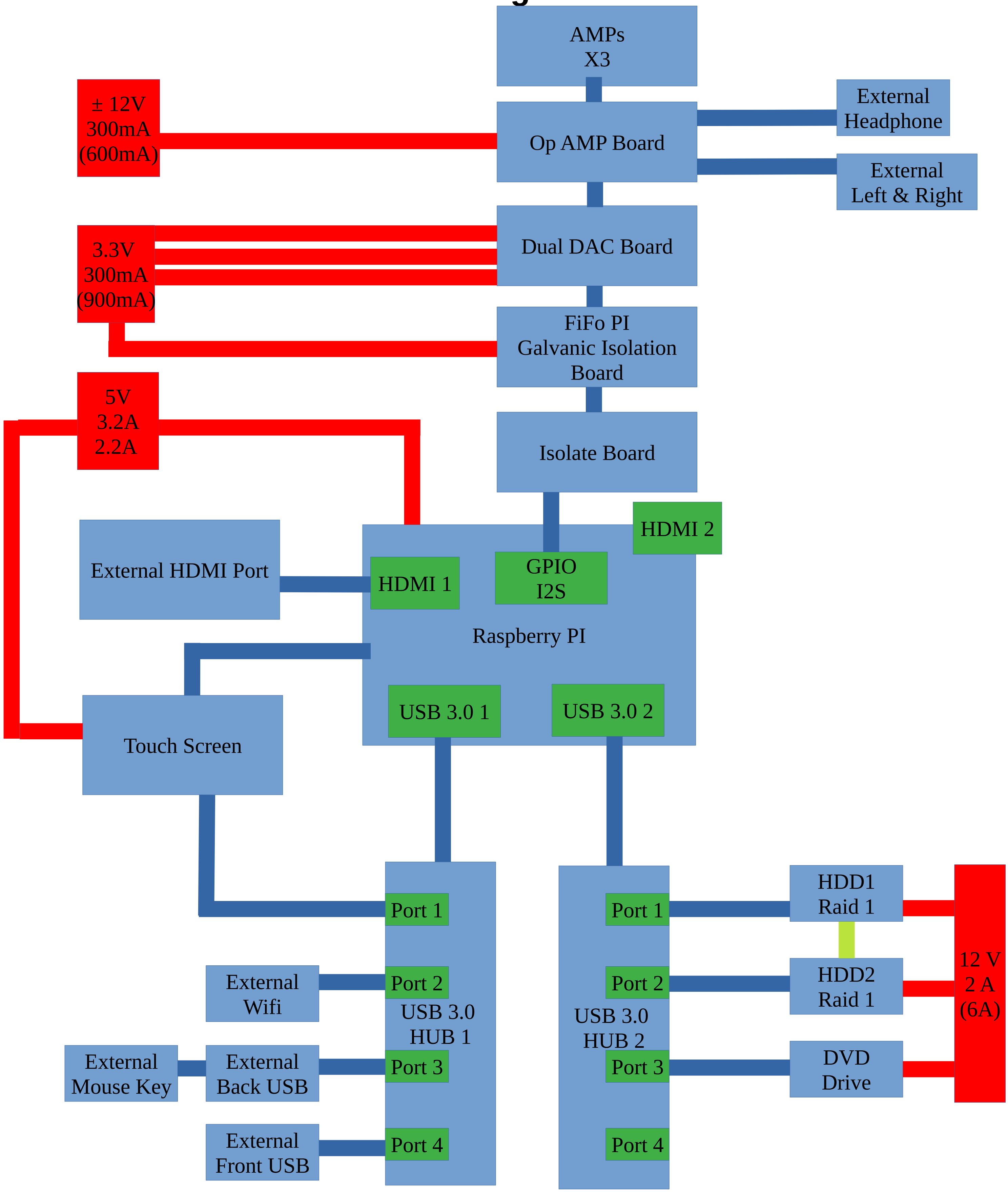
The goal of this project is to create a High Fidelity Digital to Analog Converter system that can support high end PCM files (32bit 768kHz) and DSD files (1024). To achieve this a Raspberry Pi platform is used to handle the media through linux configurations and using Volumio as an interface. The physical hardware is a combination of Ian Canada products, Raspberry Pi, and Kenyon Engineering Design for low noise and extreme voltage regulation power supply board.

Table of Contents

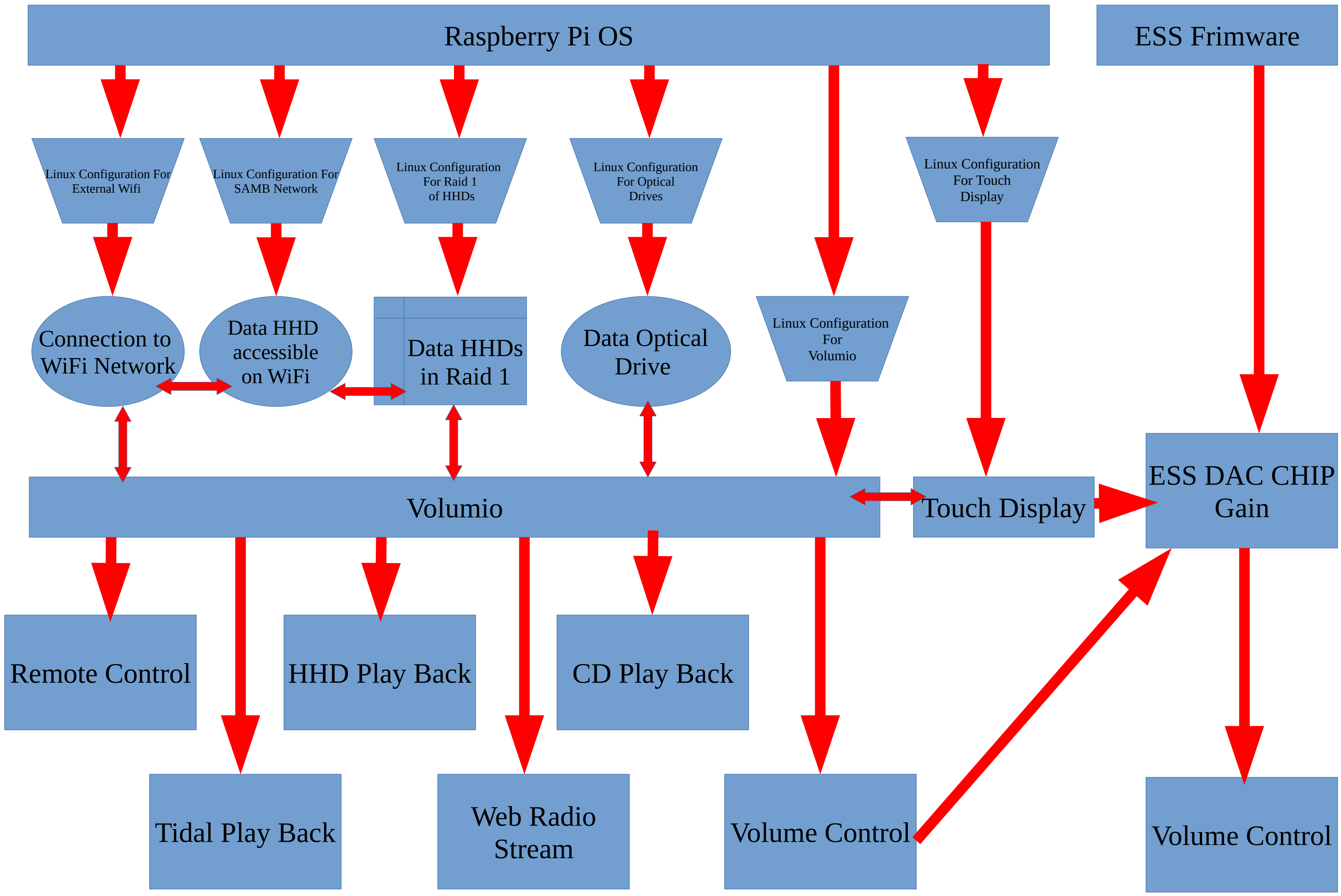
Functions:

1. Streaming Music
    1. Volumio on Raspberry Pi4
        1. Tidal
            1. PCM
        2. Radio Stream
            1. PCM
    2. External WiFi module to enable external radio antennas
        1. Additional USB 3.0 Port
        2. Configured on Raspberry PI OS on Pi, and code will be written to configure module.
2. Record onto & play from Hard Drive
    1. Raspberry Pi OS on Raspberry Pi
        1. Code will be written to have drive recognized and configured.
        2. DSD 64-512 file format
3. Play CD Formatted
    1. Raspberry Pi OS on Raspberry Pi
        1. Code will be written to have drive recognized and configured.
4. Samba Network Drive
    1. Raspberry Pi OS on Raspberry Pi
        1. Code will be written to have drive recognized and configured.
5. Raid 1
    1. Raspberry Pi OS on Raspberry Pi
        1. Code will be written to have drive recognized and configured.
6. Video Out 4k
    1. Native Raspberry Pi OS on Raspberry Pi
7. USB Stick Ready
    1. USB extension Cable
8. DAC
    1. I2S native on Raspberry Pi
    2. Ian Canada System
9. DAC Volume Control
    1. ESS Control Module
10. Video Streaming
    1. Native Raspberry Pi OS
        1. Internal pulled from external wifi module
11. Headphone Out
    1. Native DAC system from Ian Canada
    2. Need to add extension
12. Control
    1. Volumio on top of Raspberry OS
    2. Connection to Local Network via external wifi module
13. Touch Screen
    1. Native HDMI from Raspberry Pi
    2. Connected to USB hub
14. External Mouse & Keyboard
    1. External Case USB port
    2. USB Extension Cable
    3. Connected to the USB hub

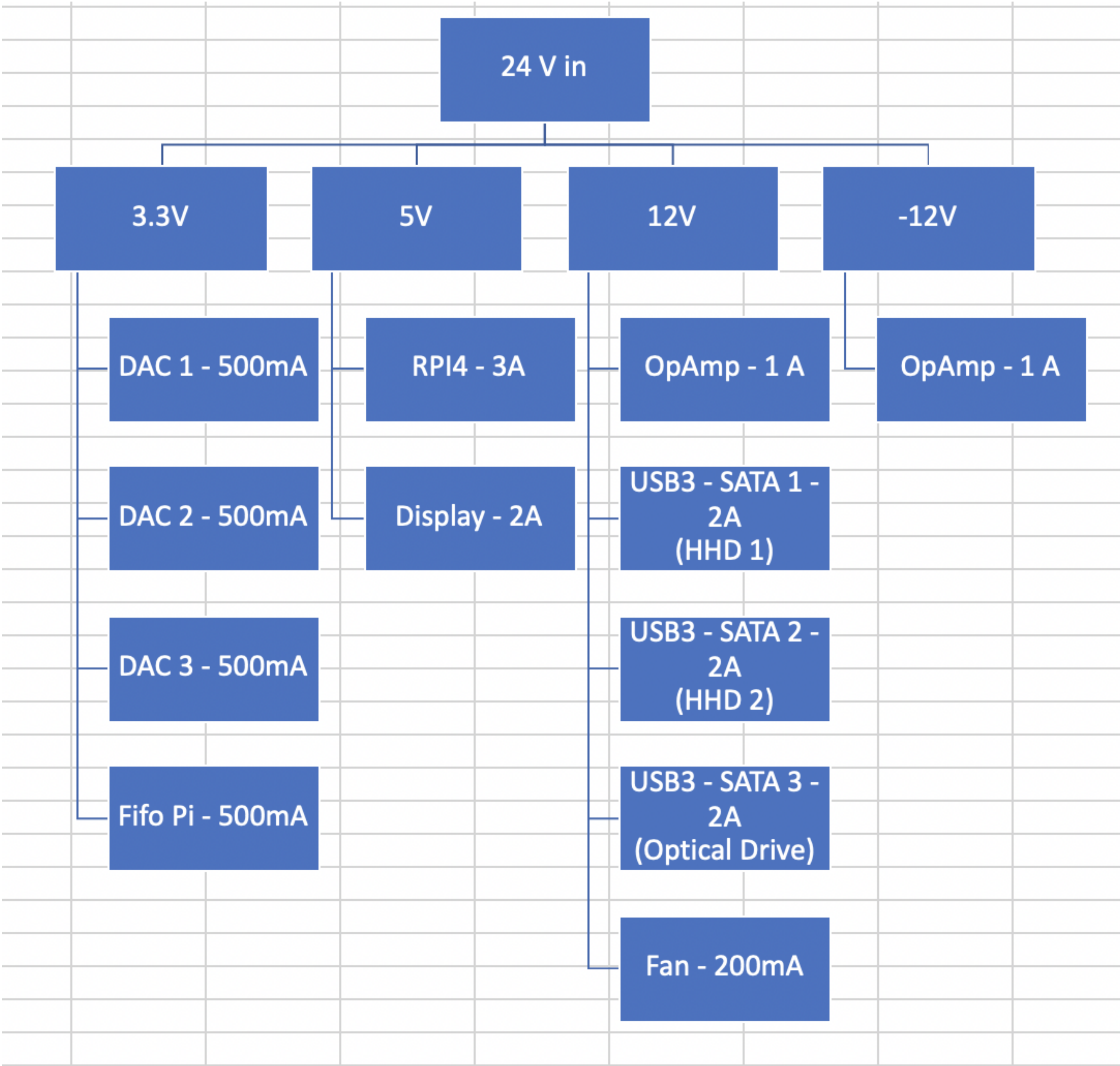
Hardware Functional Block Diagram:



Software Functional Diagram:



Power Supply Functional Diagram



Integrated Circuits

Part	Number	Section	Type	Manufacture	Quantity
JCK1524S05	JCK1524S05	24V-5V	IC	XP Power	1
LT3045	LT3045EMSE-1#PBF	5V-3.3V	IC	Analog	4
LTC6655	LTC6655BHMS8-3.3#PBF	3.V REF	IC	Analog	4
LT1084	LT1084CT-12#PBF	15V-12V	IC	Analog	2
LT1084	LT1084CT-5#PBF	7V-5V	IC	Analog	1
JCD0624D15	JCD0624D15	24-15V,-15V	IC	XP Power	1
LT1086	LT1086CT-12#PBF	15V-12V	IC	Analog	1
LT3015	LT3015IQ-12#PBF	15V-(-12V)	IC	Analog	1

IC Selection

The challenge was to get low noise regulators with high precision and tight control to supply the various rails without designing an AC to DC conversion circuit. This led to looking for a power supply to do the conversion to AC to DC with minimal EMI, noise, small package, and responsible cost. This led to a purchase of a Meanwell supply that the output voltage is 24 volts. Thus the IC selection and design considerations revolve around the 24 volt input and the desire for high quality rails.

3.3 Volt Rails

The start of the 3.3 Volt rails come from a XP Power DC/DC switching transformer to bump down to 5 volts. This unit has a good regulation capabilities with relatively low noise. Next, the power flows through a capacitance multiplication circuit with multiple caps with different ESR profiles to ensure a broadband of filtering and also reduce the voltage a little more from the NPN transistor. The trade off is that the leakage current is higher, but I am willing to waste power in order to achieve a better rail. After this there are several decoupling capacitors on the LDO and Voltage Reference. The LDO selected was an Analog device due to the IC performance specifications, ability to be put in parallel (future design), Kelvin Sense (not used), and package size. These rails are undoubtedly the most important in the power board due the components this powers; FiFo PI and DAC. Thus any noise in any of the rails will be transmitted into the system and possible into the output analog signal from the DAC. Thus so fair 90% of my effort has been spent designing and thinking about these voltage rails. Lastly, I still need to choose a DC/DC buck converter for this section

5V Volt Rail

Next is the 5V voltage rails, this is system power and display power. The only challenge with this section is the high power usage 15 watts. Thus, any LDO chosen needs to have an input voltage closer to volts to 5 volts or to ensure that heat generated is properly dissipated into the housing. I decided to go with the later due the package size and features of an LT1084. Thus, I spent quite a bit of time finding through hole heatsinks that can be attached to the LDO and allow for air flow to pass in the case. What is a nice bonus, is that amperage rating of the LT1084 enables me to run both the PI and Display off one regulator thus saving some money.

12 Volt Rail

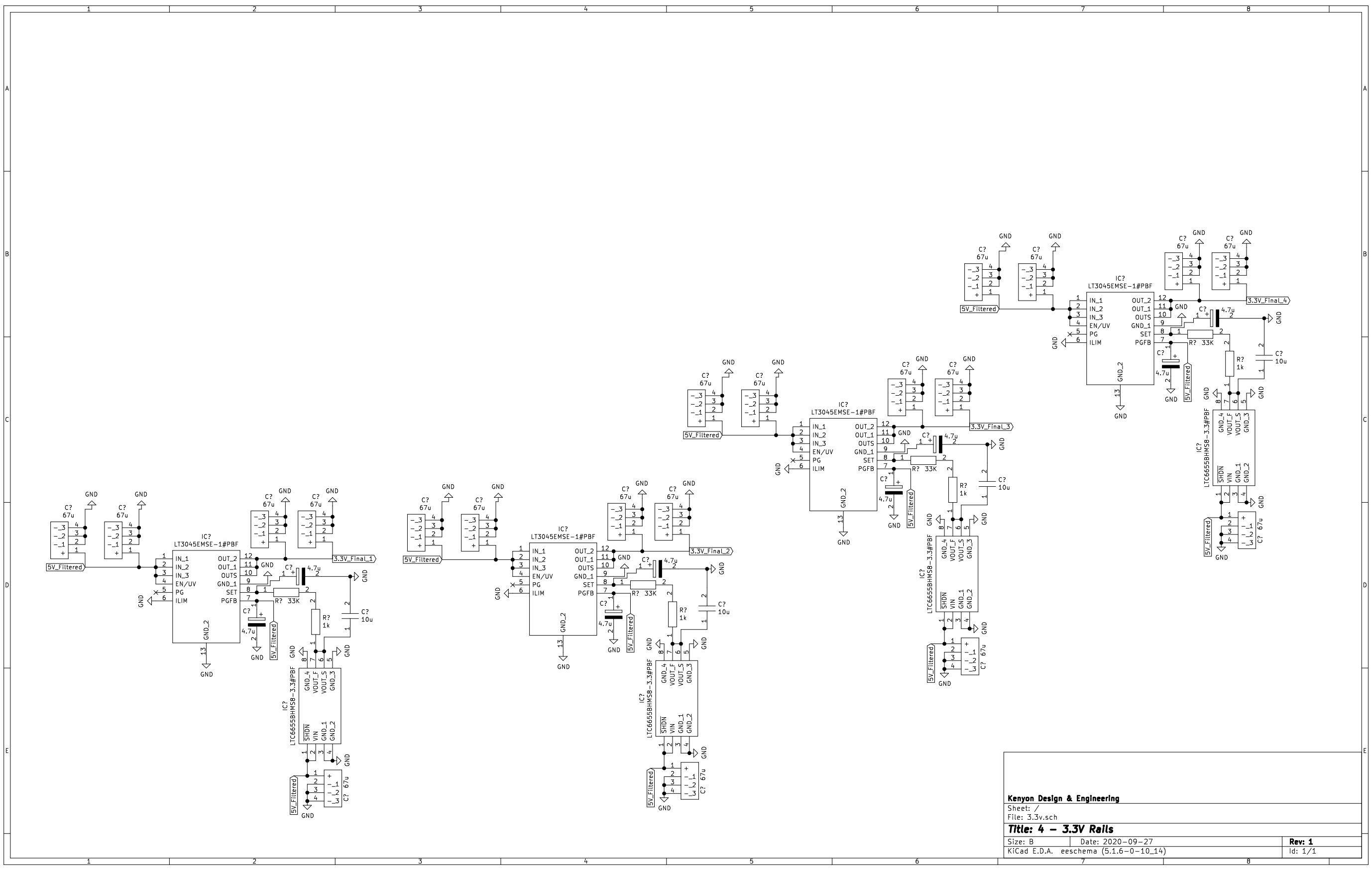
The 12 Volt rails are another system level power section. This section powers the HHDs and Optical drive. Thus, they need just standard tolerances and control. The IC chosen for this was another LT1084. However, the only issue like the 5 Volt rail is choose a buck to bring the input voltage closer to 12 to reduce heat generation.

± 12 Volt Rail

This rail is another critical rail due to that this section provides power to the OpAmps. Thus the goal to reduce noise here as well like the 3.3V. This section comes from a XP Power DC/DC Buck Regulator with positive and negative rails. This enable to tight LDOs from Analog / Linear Technologies to get the power into the Op Amps clean and tight. The two ICs selected from Analog have great performance and coupled with high quality decoupling caps and capacitance multiplication circuits will drive the noise down.

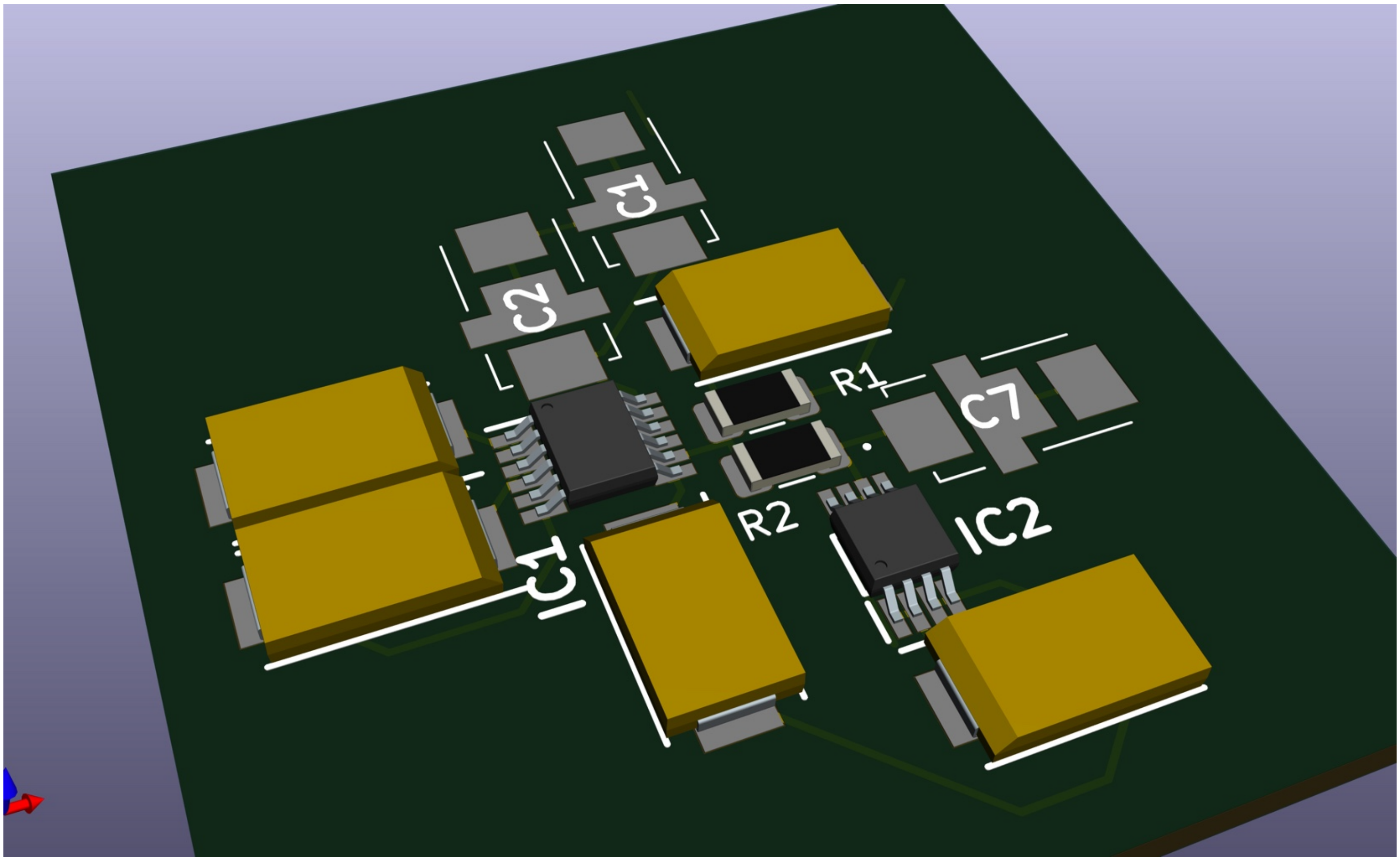
3.3V Schematic

This is the final schematic for the four 3.3 volt rails.



PCB Layout

Below is a ROUGH PCB layout for a single 3.3 Voltage rail. There are lots of mistakes; like the ground copper pour is not connecting all grounds together. Another mistake is trace size for voltage in and voltage out. Another mistake is the phoenix connectors are not present in the system. Lastly, the critical decoupling capacitors C2, C1, and C7 are not shown due to not having the models updated in KiCAD.



Pictures