ANALOGBLOX™
TRIPLE OUTPUT POWER SUPPLY
PWR001

For Revision 2 hardware

Rev 3.0

30-Dec-2019

Signal Processing

http://clk.works/

1. TABLE OF CONTENTS

Attachment: Schematic.

1 INTRODUCTION

The Clockworks PWR001 provides +/-15V 330 mA and 3.3 V 1 amp outputs for use in the AnalogBlox portion of a SignalBlox system. It is generic enough that it can be used in any general power supply application. It's powered by a 12 VDC input. One of its more unique features is the ability to signal loss of power and hold up the outputs for up to 10 msec after loss of primary input. This allows the system controller time to ramp down volume levels and engage output muting circuitry to minimize clicks and pops on unplanned power loss.

The module provides control of the +/-15V supplies to enable a host controller to enable analog supplies after the digital portion of the system is in a stable, operational state.

The supply has been designed to efficiently provide clean, low noise analog power without the need to use LDOs in the system design. Measurements performed during the design evaluation showed that analog audio systems using this supply can achieve SNR of better than 120 dB without resorting to local LDOs.

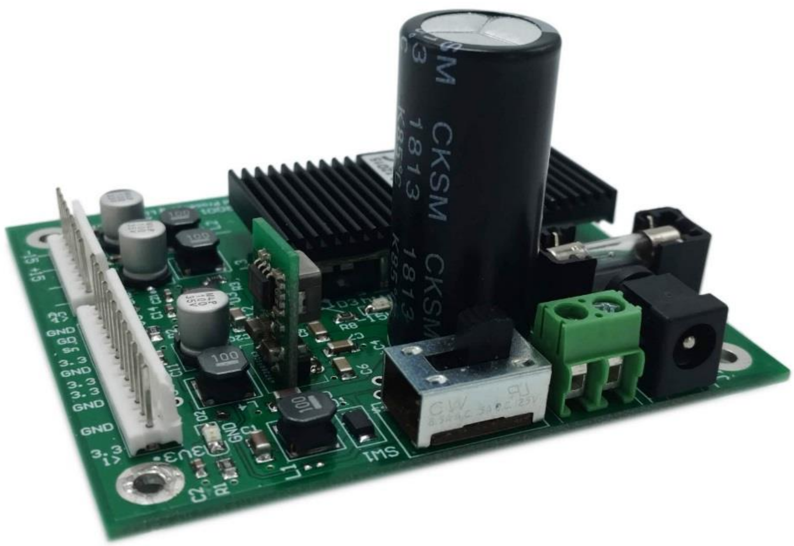

Figure 1 PWR001 module

1.1 MODULE DESCRIPTION

The PWR001 module is a SignalBlox standard sized 75mm x 85 mm module with two MTA-100 style connector headers for supply outputs and control. The pinouts are the same as those described in the SignalBlox System Configuration Guide.

One of its more unique features is the ability to signal loss of power and hold up the outputs for up to 10 msec after loss of primary input. This allows the system controller time to ramp down volume levels and engage output muting circuitry to minimize clicks and pops on unplanned power loss.

Outputs are:

- +3.3 at 1 amp (always on output for powering standby/host controller)
- +/-15V at 330 mA, intended for use by analog circuits

For full details please see the schematic (at the end of this document) and associated layout files (available from the Clockworks website).

It is operated from a 12V supply via a standard 2.1mm (center positive) barrel connector or screw terminal block for discrete wire. An input diode is used to protect against reversed input supply. A 5 x 20mm 1.6A slow blow fuse provides a good failsafe against system damage that might occur when developing prototype systems.

Details about the power supply design and its initial testing can be found in the TechNotes section of the Clockworks website[1].

1.2 HOW SUPPLIED

The PWR001 is supplied in two standard configurations:

- PWR001 board only.
- PWR001, 12V supply (choice of North American and Universal AC plug versions for the supply), spare fuse, and two MTA-100 cable assemblies

1.3 SPECIAL VERSIONS

The supplies have a number of through-hole components that can be changed during final assembly to accommodate a number of alternate versions of the basic three output board.

[1] Many of the scope captures included here are from those documents.

1.3.1 INPUT VOLTAGE RANGE

The module can be ordered with an extended input range of 10V to 24V for use where a regulated input supply is not available. A different capacitor for the hold up function is used, please contact Clockworks for more information.

1.3.2 OUTPUT VOLTAGE OPTIONS

The digital 3.3V output can be changed to 5V. For details on the digital output voltage option see the CUI VXO78-1000 series datasheet. The standard board uses the VXO7803-1000 regulator; the VXO7805-1000 regulator can be used for 5V output.

The +/-15V output (@ 300 mA) can be changed to +/- 5V (@ 1 amp) by using the Meanwell NSD10-12D5 module instead.

In both cases the changed output voltages appear on the correct pins of the MTA-100 output connectors and the original pins are removed. For example this board is configured for +/- 5V output:

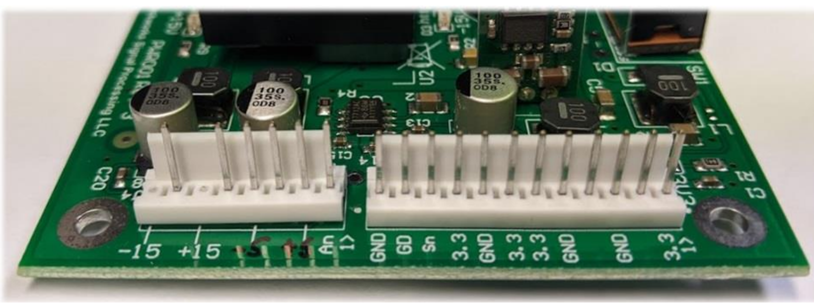

Figure 2 Custom version with +/- 5V output (pins for +/- 15V are removed on the left connector)

1.4 SOFTWARE SUPPORT

The PWR0001 module can be controlled by the system host processor, which would use two GPIO lines to interface with the PWR001 module. One GPIO line monitors the power good signal and should cause an interrupt on loss of power. The other GPIO line controls the analog supply. No special software is needed, though the power fail signal should be connected as an NMI to ensure minimal delay in reacting to the loss of power.

For systems without a host processor, the analog enable line should be jumpered low. The power fail signal can be used to directly control any available hardware muting functions.

1.5 INPUT POWER REQUIREMENTS

Under full rated load the board provides 13W of power. With typical regulator efficiency that corresponds to about 16W of input power, or 1.3 Amps for a 12V supply.

The supply design includes a 10,000 uF electrolytic capacitor at the input[2] and during a cold start situation the external supply will see a brief current spike that lasts for 1 msec and peaks at about 14A. Some small 12V supplies will trip with a load current like that and shut themselves off for a few seconds, during which time the cap discharges.

The Clockworks 12V supply in the kit version has been tested and found to not have issues with startup.

2 CONNECTOR & MECHANICAL INFORMATION

2.1 INPUT CONNECTORS

The input barrel connector, a CUI PJ-050AH, is configured center positive. The input voltage should nominally be 12V, but the supply can operate with 10 – 13V (higher if the holdup cap is switched to a 35V unit).

Alternately the Phoenix Contact 1935161 (5 mm centers) terminal block can be used with wire sizes from 14 AWG to 26 AWG.

2.2 OUTPUT CONNECTORS

There are two output connectors for power, one conforms to the 12 pin SignalBlox standard for digital power and the other the 8 pin standard for analog power. Both are from the TE[3] MTA-100 series of connectors, part numbers 1-640454-2 and 640454-8[4]. The mating part numbers (for closed end style) are 4-643813-2 and 3-643813-8. These are designed for 22AWG stranded wire, which is the largest wire size supported with MTA-100 connectors.

Table 1 and Table 2 show the pin assignments as well as the normal wire color used in the cable assemblies provided by Clockworks. For more information on the Clockworks cable assemblies look up part numbers CA002 (12 pin) and CA001 (8 pin).

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[2] That cap is there as a simplistic/low cost way to hold up the outputs to allow analog outputs to be gracefully muted during an unexpected loss of power. It also provides some filtering of the 12V supply, though its higher ESR/ESL doesn't help for high frequency noise.
[3] Formerly Tyco Electronics.
[4] These have a tab to ensure alignment when used with the mating connector with tabs. It does not have the locking ramp as extensive force is needed to unmate the connectors if that was used.

Table 1 : 12 pin digital power connector

Pin	Signal	Wire color
1	+3.3STDBY	purple
2	NC (+5)	red
3	GND	black
4	GND	black
5	NC (+5)	red
6	+3.3	orange
7	+3.3	orange
8	GND	black
9	+3.3	orange
10	NC (DIGPOWERn)	green
11	PWRGOOD	grey
12	GND	black

On the PWR001 module there is no +5V digital supply so pins 2 and 5 are no connects (NC), shaded blue in the above table.

There is only one 3.3V supply and it powers both the +3.3STDBY and +3.3 pins. This also means the DIGIPOWERn signal is not connected, since there is no secondary digital supply to control.

Table 2 : 8 pin analog power connector

Pin	Signal	Wire color
1	ANAPOWERn	green
2	NC (+5)	pink[5] (or brown)
3	GND	black
4	NC (-5)	white
5	GND	black
6	+15	yellow
7	GND	black
8	-15	blue

On the PWR001 module there is no +/- 5V analog supply so pins 2 and 4 are no connects (NC), shaded blue in the above table.

To enable the +/- 15V output the ANAPOWERn pin should be pulled low. The pin may driven by a OC output or an active output up to 5V. It will float to 3.3V. Input current is -0.25 mA when pulled low.

3 REGULATOR INFORMATION

The use of standard regulator modules allows the characteristics to be determined from their datasheets.[6] To save fishing around for those we've copied in some of the information to here.

Please note the maximum C values that are suggested. The PWR001 module has 100 uF on each output, and that should be subtracted from the numbers provided here.

3.1 MEANWELL NDS-10D15 (+/- 15V)

- Voltage tolerance: +/-2.5%
- Line regulation: +/-1%
- Load regulation: +/- 1%
- Max C: 1000 uF
- Max input current: 1.4 A

[5] Pink is an uncommon color so brown is used for this when pink is unavailable.
[6] OK, try not to laugh…power supply datasheets are all notoriously lacking in helpful information about how they might work in real circuits.

3.2 CUI VXO7803-1000 (3.3V)

- Voltage tolerance: +/-2% (typ), +/-4% max
- Line regulation: +/-0.2% (typ), +/-0.4% max
- Load regulation: +/-0.4% (typ), +/-0.6% max
- Max C: 680 uF

4 POWER SEQUENCING

Additional details can be found in TecnNote TN002, available on the Clockworks website.

The supply voltages all ramp to their final voltages in under 20 msec and the power good signal becomes active 70 msec later, see Figure 3. In that capture the analog enable is jumpered low. The 3.3V supply starts up in a time comparable to the +/-15V.

Load conditions will affect these numbers, and for full details the regulator datasheets should be reviewed.

The power good signal indicates the status of input power, not the voltage at the output of the regulators. If a load short is present the power good signal will still activate.

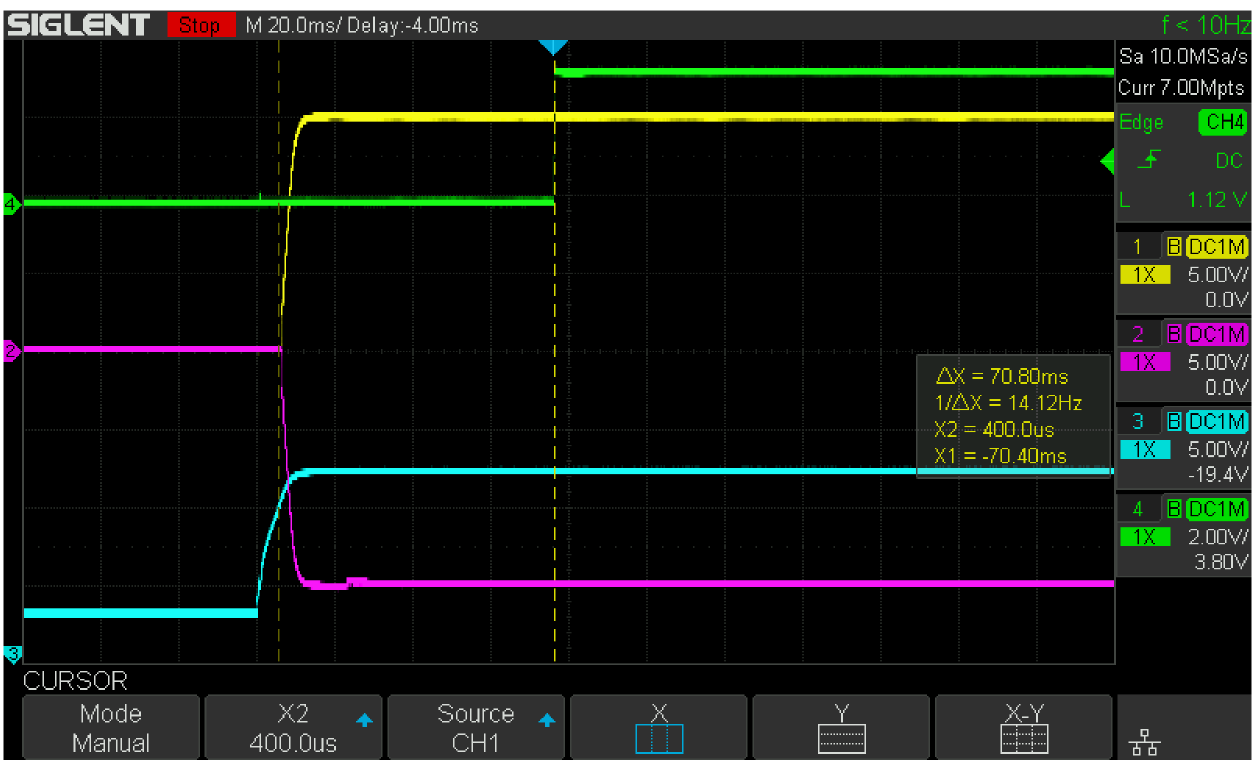


Figure 3 +15V (ch1) Yellow, -15V (ch2) Magenta, 12V in (ch3) Blue, PowerGood (ch4) Green

The amount of holdup time depends on the load. The next example, Figure 4shows the power off timing with around 7.5 watts of loading. This is for a hard power off. If the input 12V supply decays slowly this can add to the time, though as was demonstrated in TN002 it can also slightly degrade the time as the analog regulators start collapsing but the voltage supervisor has not tripped yet.

With a 12W total load holdup time is around 12 msec. System designs should assume that less than 10 msec is available, though in practice with less than full loads plus normal distributed filter capacitance on the supply rails times should exceed this number.

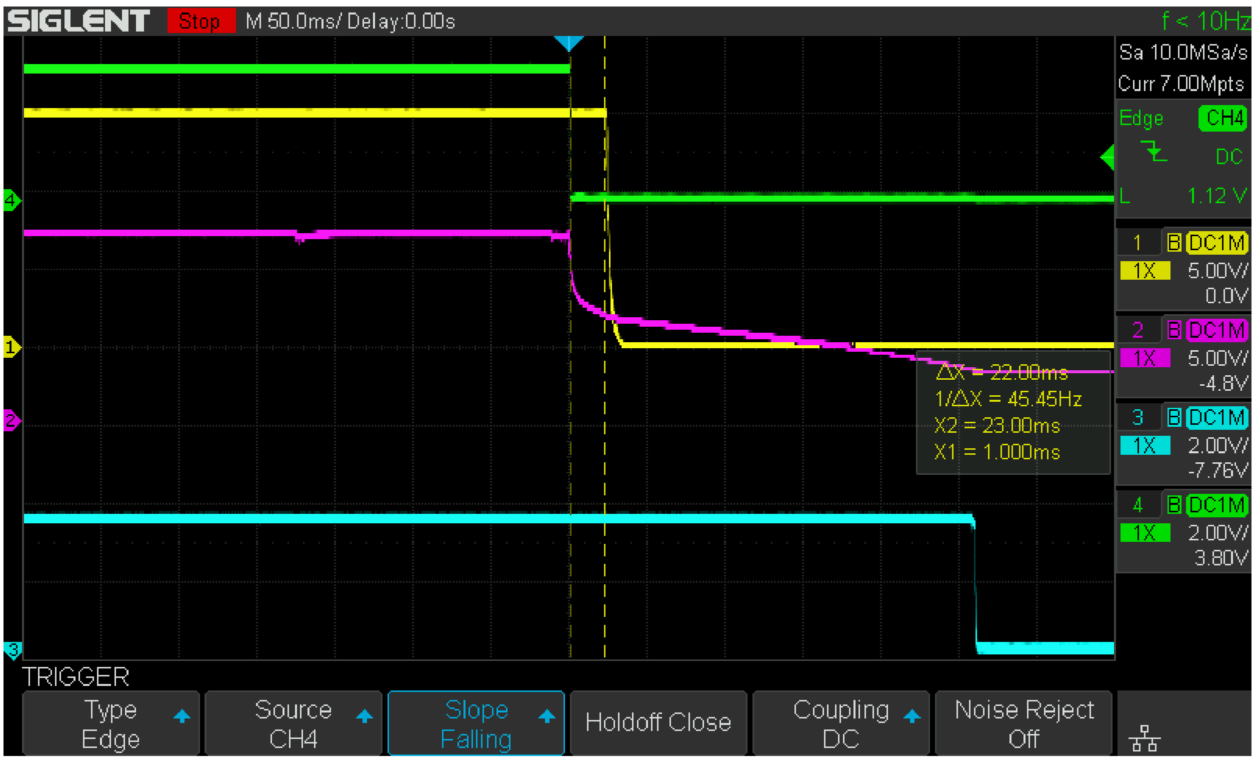
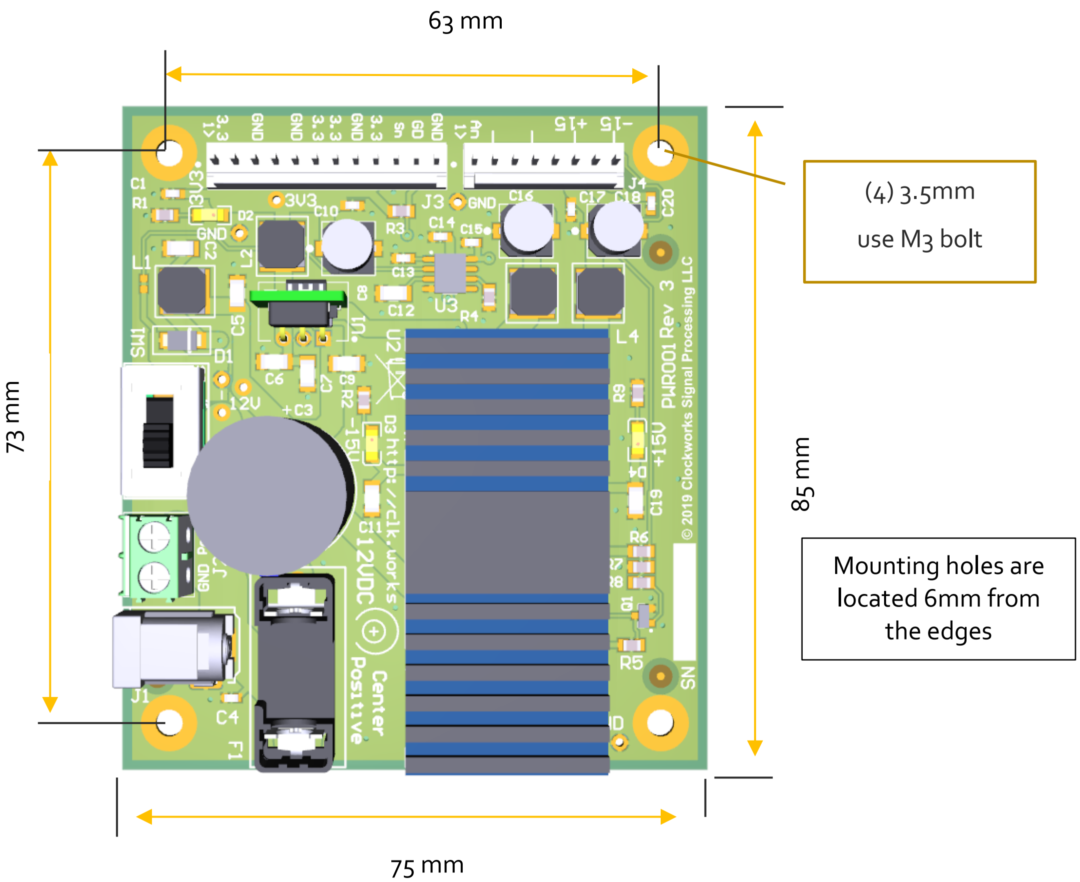


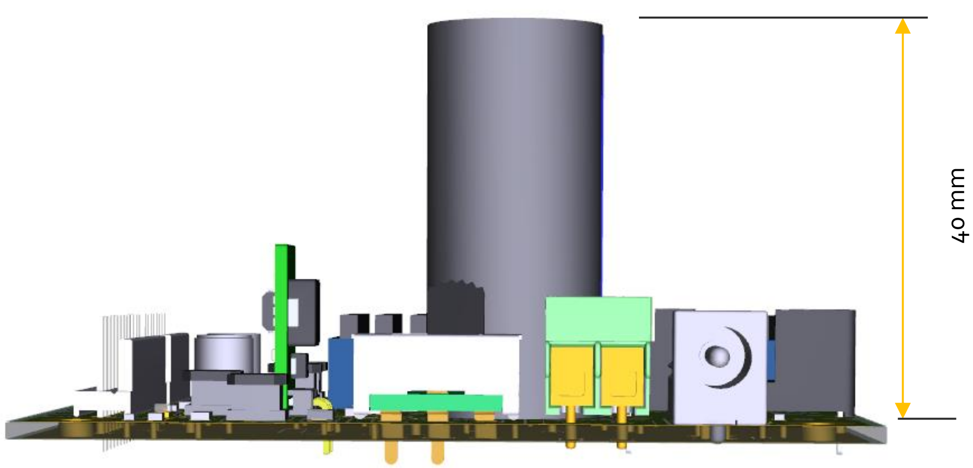
Figure 4 Switched to off. +15V (ch1) Yellow, -12V input (ch2) Magenta, 3,3V (ch3) Blue, PowerGood (ch4) Green

4.1 MECHANICAL

The 4 mounting holes are connected to the ground plane. The tallest component (the hold-up capacitor) top is 40mm over the board. The switch leads protrude 3mm below the board. The PCB is standard .062 (1.6mm) thickness.

Assuming typical efficiencies for a 12V supply input, the board is calculated to dissipate about 3W of power. No special cooling considerations should be needed, though it should not be placed in the airpath of other system components that create heat.





Power switch shown in off position

The working temperature of the regulator modules is specified as -25 to +70C. The other components on the board work across a wider range. OTOH heat is the general enemy of long electronics life so placing the supply where it's not next to other hot components as well as can have some natural convective flow is desirable.

5 DESIGN CONSIDERATIONS

The supply board uses a 10 uH choke and 100 uF capacitor to attenuate the switching noise from the bipolar supply. This filter has a Fc of 5 kHz. With assumed DCR/ESR from the part's datasheets there is a bump in the simulated response around Fc as system Q is > 1, but it was not observed in the measurements.

In actual system additional decoupling capacitors would be used near the loads. However for the switching regulators to retain their load transient response there is the competing desire to minimize load capacitance. The tradeoff is further complicated by the noise spectrum of the regulators having a dependency on the current.

SignalBlox carriers provide additional capacitance, typically an additional 200 uF. Each module (analog or mixed signal) is assumed to place an additional 100 uF on each analog supply, though not all boards use all voltages. This places a typical additional capacitance of 400 – 600 uF on the analog supplies. This lowers Fc to around 2 kHz and the Q is closer to 1.

5.1 MEASURED NOISE

These numbers are from a sample and do not indicate a guarantee of performance. They were measured with resistive loads on the +/-15. TechNote 004 has further details on the regulator noise variations with load current. The + and – outputs were found to have the same noise values.

Measurement bandwidth is 22 kHz. Power was from the 12V AC adapter typically supplied with the board. Some weighted measurements are included to give an idea where the noise is; use of A weighting would be a definite cheat for specifying performance. Actually FFT plots are included later.

Load/Capacitance added	Measurement weighting	RMS noise dBV	RMS noise uV
200 mA/None	-	-89.5	33
200 mA/None	C	-92	25
200 mA/None	A	-95.5	17
200 mA/470 uF	-	-92	25
200 mA/470 uF	C	-92.5	24
200 mA/470 uF	A	-102	8
45 mA/None	-	-91	28
45 mA/470 uF	-	-92	25

6 GETTING STARTED WITH THE MODULE

In the kit configuration the board is supplied with a 12V power supply and 8 pin and 12 pin MTA-100 cable assemblies. Connect the two MTA-100 cables to the board and your device. Ensure that the pins are lined up; there are polarizing tabs but enough force will break them off. Don't do that.

Make sure the power switch is in the off position.

Plug the 12 V supply in to the barrel connector and the plug the wall wart in to the AC power.

Flip the switch to the on position. The 3.3V LED should illuminate. Enable the analog supplies from your target board (i.e. pull the ANAPOWERn low, OK to ground it for always on). The +15 and -15V LEDs should illuminate.

Verify your load is receiving the correct power. If one or more of the LEDs fails to light your load may be shorting the supply rail. If all of the LEDs fail to come on verify the 12V supply is operating and check that the fuse has not blown. There is also a 12V test point on the PCB near the power switch.

6.1 OTHER THINGS

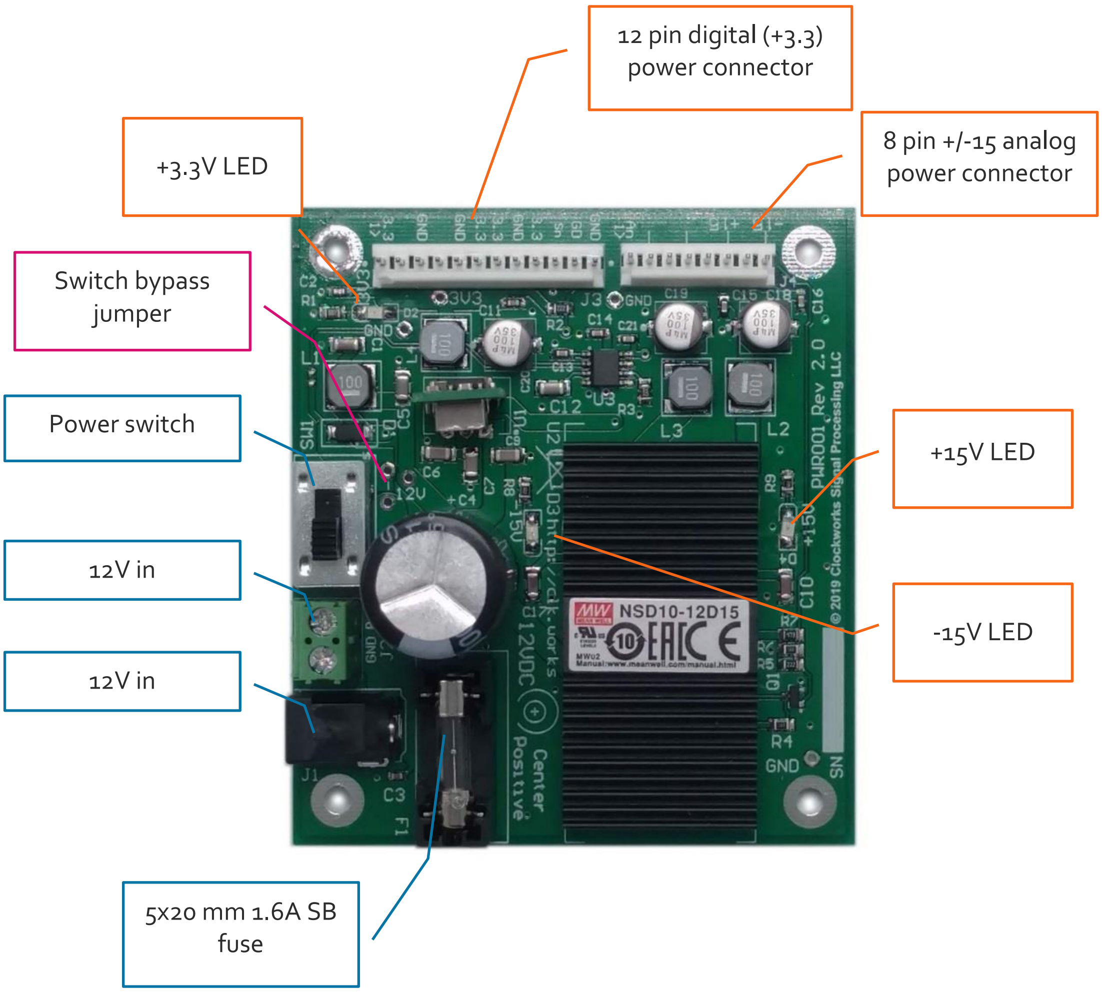


Figure 5 Board feature locations

There are a pair of jumper holes next to the switch. If the switch needs to be disabled to prevent accidental system shut off, a small wire jumper can be soldered in to the two holes next to the switch.

6.2 +/-15 SUPPLY NOISE

TN001 investigated the impact of the +/- 15V supply noise on actual op-amp circuits. The spectrum here are the outputs of the supply under different current loads and with and without 470 uF of additional load capacitance. Both the positive and negative outputs are captured, though as can be seen in the plots they are basically the same.

All plots are 16K point FFTs with 16 averages. The noise in the 60-70 kHz range is background noise on the bench and not part of the supply output. Vertical axis is in dBV.

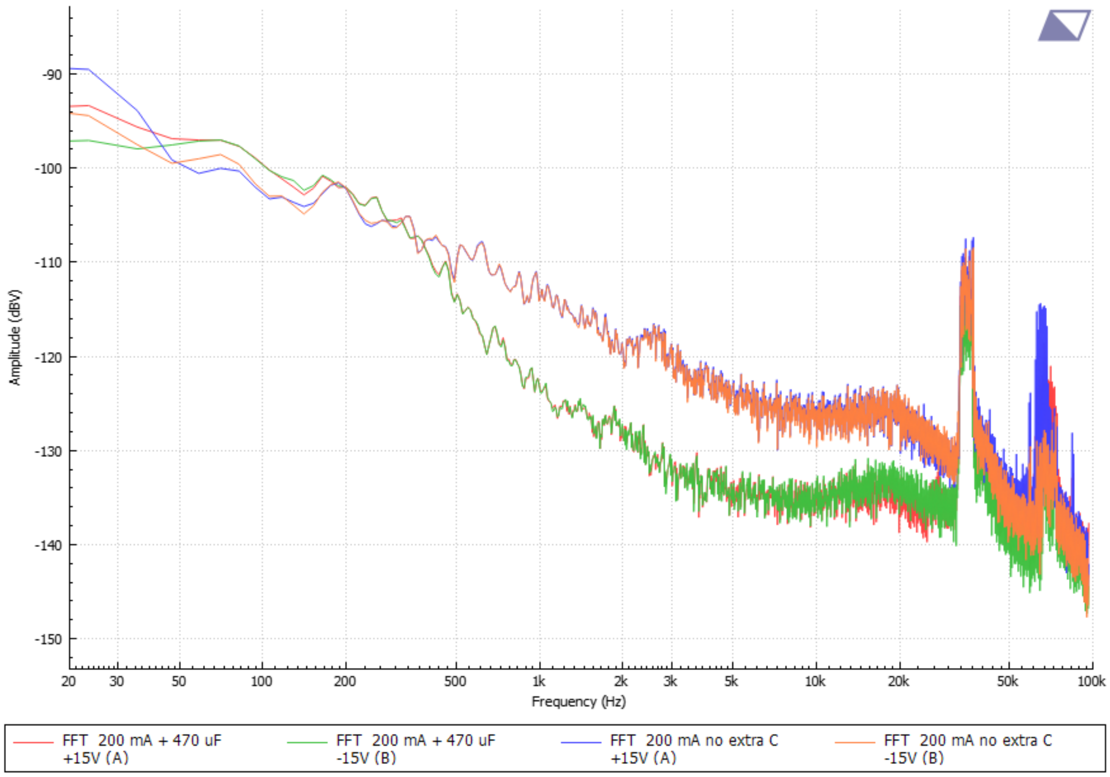


Figure 6 200 mA load showing effect of adding 470 uF on noise spectrum. Total noise in the audio band (22 kHz BW) reduced 2.5 dB.

While the switching frequencies of the supply is around 500 kHz (controller is TI TL3843) the control modulation creates frequencies that can fall in the audio band, particularly this is usually observed under light loads. The following plots with 100 mA and 45 mA loads illustrate this.

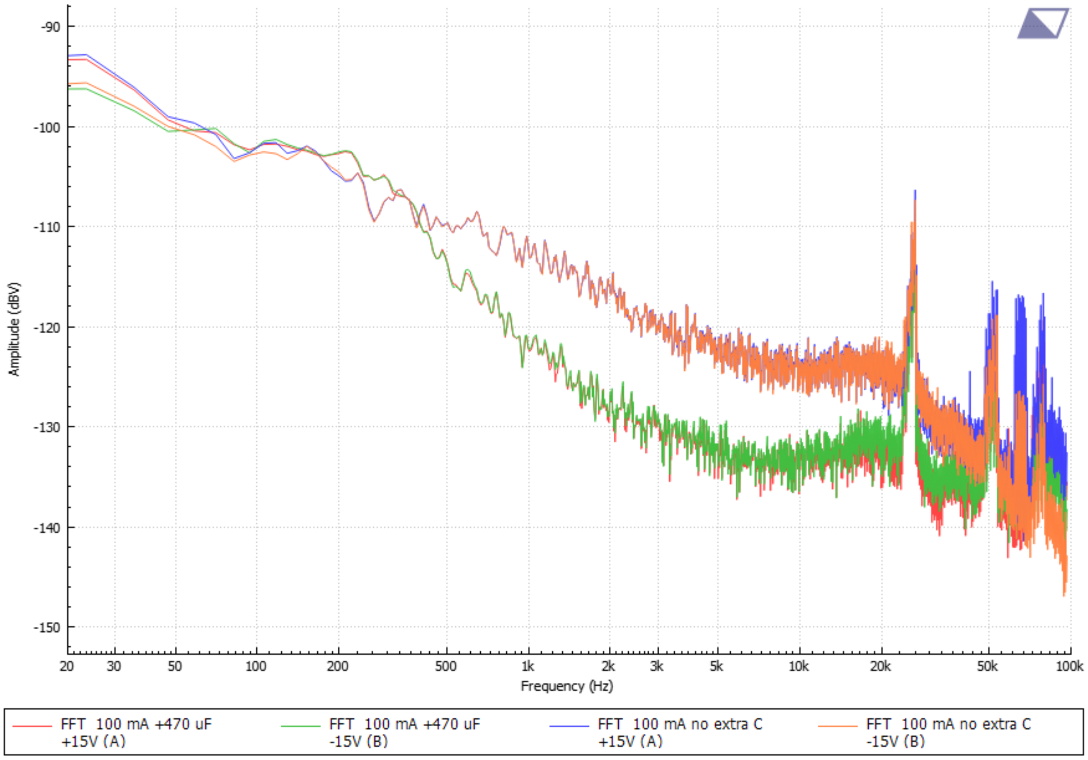


Figure 7   100 mA load showing effect of adding 470 uF on noise spectrum.

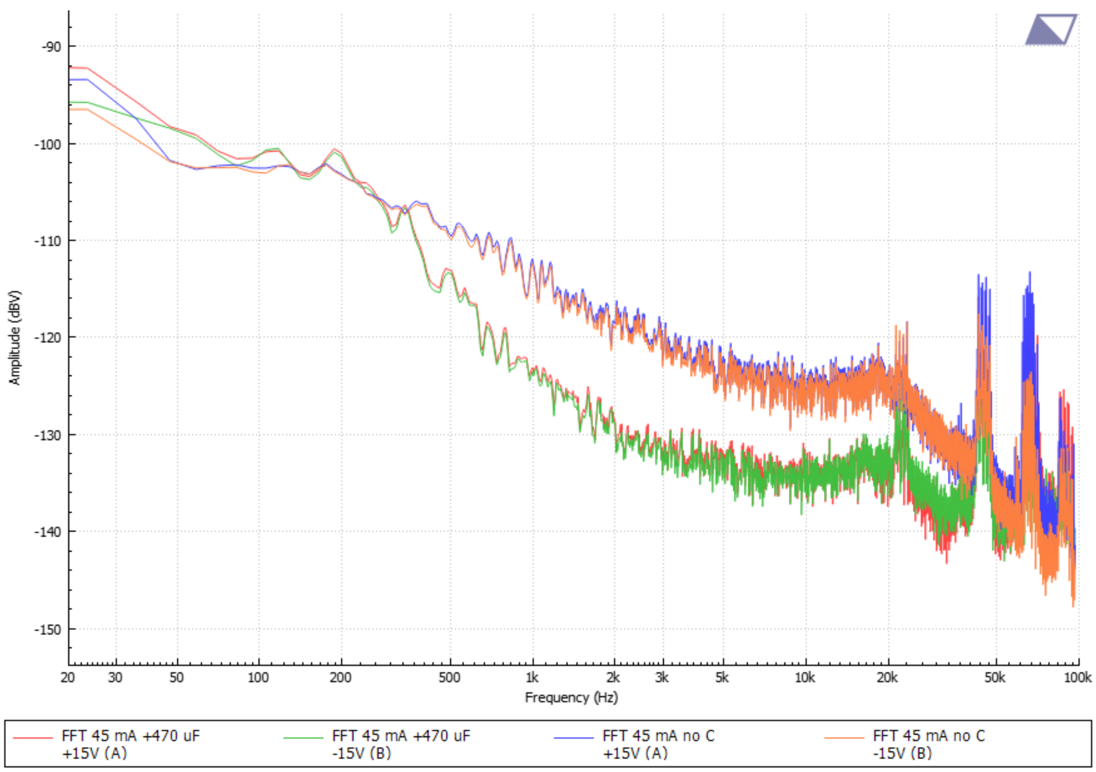


Figure 8   45 mA load showing effect of adding 470 uF on noise spectrum.