Hifisonix Standard PSU

Low noise +-18V Linear PSU with Mute Relay Driver function, +5 or +3.3 Digital PSU, +12V Relay supply and Ground Lifter

Andrew C. Russell

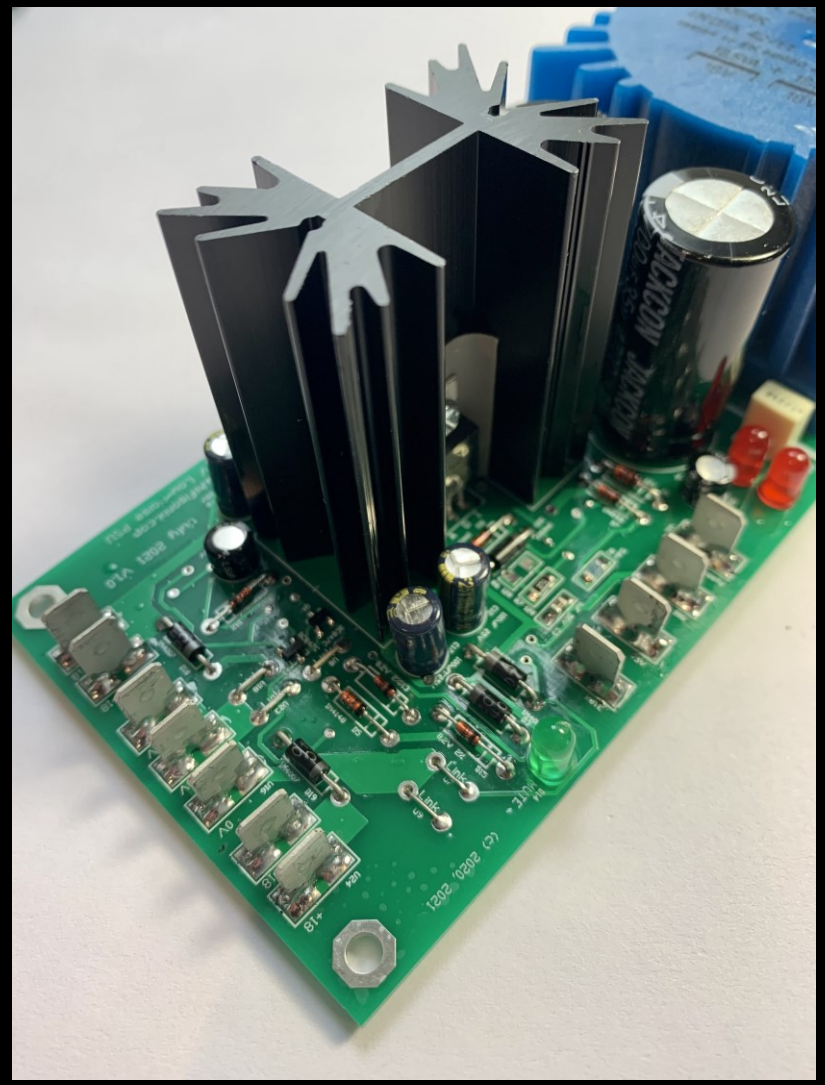
July 2021

www.hifisonix.com

Important: This project is strictly for DIY/personal use only. If you wish to use this design, or aspects of this design, for commercial applications and/or resale, kindly contact me via the hifisonix website or at bonsai(at)hifisonix.com

Click here for Double sided, silk screened PCB's for the Standard PSU

This project uses through hole leaded components and SMD down to SOT23 and 0805




To Chassis
July 2021 V1.0
www.hifisonix.com
+-18V Low Noise PSU

WARNING

This project is intended for experienced DIY constructors.

This project involves wiring up mains voltages.

Do NOT attempt this project unless you are completely aware of the dangers of mains voltages and fully understand mains voltage wiring practises and conventions.

A wiring mistake can be lethal. Do not take any risks.

Seek professional advice if you are not sure.

Always adhere strictly to the electrical regulations in your country.

Hifisonix Standard PSU - Specifications

A low noise General Purpose Linear PSU for Preamplifier and Headphone Amplifier Applications

- Compact - 170mm x 75mm X 50mm (L x W x H)
- Johnson noise (aka thermal noise) and mains hum < 100 uV 20Hz – 20 kHz at full load (see measurements later in this document)
- Uses low noise Nuvotem Talema PCB Mount transformer (15VA or 25VA)
- 120 or 240 VAC operation
- +-18V DC output
- 25VA or 15 VA versions
- +-400mA per rail (25VA version) or +- 300mA per rail (15VA version)
- Incorporates MUTE relay driver function
- Includes a +12V at 40mA relay power supply
- Built in +5 or +3.3V regulator output at 60mA to power auxiliary micro controller
- Ground lifter function +-0.7V with optional bypass using offboard toggle switch
- Rectifier snubbers included
- Input/output connections via 6.3mm push on TAB connectors (accept Earth/safety ground wire – soldered)

Hifisonix Standard PSU - Circuit Description

+-18V Supply. AC power enters via U27 and U30 (marked AC1 and AC2 on the PCB). Flash pads FP1, FP2 and FP3 allow the PSU to be configured for either 120V or 240 V operation – the details of how to do this are shown on the circuit diagram. C6, a 0.1uF 275V 'X' cap provides series mode HF noise filtering. The transformer outputs two isolated secondaries at a nominal 18VAC. These each feed into separate 3A bridge rectifiers (D16 and D21). Each transformer secondary has a snubber network across the secondary comprising C18, C14 and R22 for the +ve regulator and C20, C13 and R21 for the –ve regulator.

The output from the bridge rectifiers feeds into the reservoir capacitors C16 and C9 (4700uF 35V), and from there into LM317 1.5A regulator IC's (U25 for +ve and U19 for –ve). The output voltage is programmed to the correct voltage by means of the resistor networks comprising R23, R6, R7 and R24 for the +ve side and R20, R8, R9 and R19 for the –ve side. Note that the 120 Ohm resistors should be trimmed for the correct output voltage of +-18V (see important points about the MUTE circuit operation later on). C11 and C12 decouple the LM317 reference, reducing the wide band Johnson noise from about 450uV to around 100uV. D11 and D12 (IN4148) discharge C11 and C12, preventing possible damage to the LM317 devices. Further stability and noise decoupling is provided by C15, C17 (+ side) and C8 and C10 (-side).

The + and – regulators are up to this point completely separate and are only combined via U18 and U23 (wire links) right at the common 0V connection. This means the reservoir capacitor charging and decoupling currents are confined within each regulator section, preventing any common impedance contamination between the regulators – the 0V connections at the output are therefore extremely clean. This also allows the regulators to be debugged separately before combining them with the links to form a split rail supply.

Diodes D18 and D19 (1N4007) prevent the rails from reversing by more than +-0.7V during power up or power down which could cause damage to the regulator IC's or any circuits it may be powering. Diodes D17 and D20 prevent damage to the LM317 devices should the reservoir capacitors C9 or C16 discharge before any output capacitance does. Two LED's (D8 and D9) provide basic +- power indication on the board.

+12V Relay Power Supply Since the output from the supply is +-18V, driving standard 12V relays requires a 6V drop. This is accomplished by regulating the +18V rail down to 12V with a simple zener + pass transistor regulator comprising Q1 (BCP56 SOT223 NPN transistor), D6 (12V), D7 and associated resistors R1 (to provide a light load), R2, R3. C4 decouples any zener noise, ensuring the output is quiet.

+5/+3.3 uController Regulator A simple circa 50mA regulator is provided to power up a microcontroller board that may be used for example for remote control functions. U4 (LM1117 SOT223) can provide up to 800mA and on this PSU more than the specified 50mA. However, any current provided via this regulator decreases the available current from the +18V rail so this should be factored in if more current is required. Further, the 5V regulator is not heatsinked to provide currents much in excess of 50mA. Most modern microcontrollers draw very little power, so 50mA should be adequate. The output voltage (5V or 3.3V) is selected by simply fitting the required output voltage regulator IC on the board – details are given on the circuit diagram. As with thee main +-18V regulator, D3 and D4 provide reverse polarity protection, while C2 and C3 provide decoupling for stability purposes.

Ground Lifter Two 8A MUR820 power diodes (D1 and D2) are placed in anti-parallel with one side going to the power supply 0V and the other to the chassis metalwork via U3. The diodes can withstand 60A surge currents for about 4 mains cycles, which is enough to ensure the RCD (aka GFI) on the mains distribution panel trips in the event of a catastrophic transformer/wiring failure that would put mains voltage onto PCB. It should be noted that this is highly unlikely, nevertheless, the eventuality is catered for. The ground lifter can be disabled (i.e. shorted out) by connecting a suitably rated swich across GLS1 and GLS2. Ensure the wires connecting to the switch are at least 2mm in diameter. ***DO NOT use the ground lifter function id your mains distribution panel uses old style fuses and no RCD/GFI.***

Mute Relay Controller. This works by sensing the +ve supply rail, and should it drop below 16.4V, the mute output switches off. The main power supply +-18V rails come up within 200-300 ms, but C5 (which is initially discharged) takes around 3-4 seconds to charge. After 200-300ms, Q3 is turned on, holding Q4 off. When the voltage across C5 reaches ~11 volts, Q2 (BUK78150-55A standard gate voltage level mosfet) switches hard on. D12 ensures that the voltage across C5 is at least 8.2V before Q2 sees any gate voltage. R12 and R13 bleed off any leakage current (up to 1uA) through D12, preventing Q2 from turning on prematurely. When power is removed, the +18V rail (which it is assumed will decrease more rapidly the -18V rail due to the normally higher load current) will drop. When it falls below 16.4V, Q3 turns off and Q4 turns hard on via R10, shorting C5 to 0V via R11 (120 Ohms), ensuring a rapid reset. Q2 is thus turned off very quickly – tests showed this was between 20 and 100mS depending on the load on the PSU. Since most small signal amplifier circuits will operate correctly at supply voltages of 25% below the nominal operating voltage, this approach ensures there are no clicks or thumps on power up or power down. D5 ensures that C5 is fully discharged once Q4 partially turns off as the supply rails get to within 1-2 V of ground.

Notes for operation where the mains voltage is lower than 120/240 VAC

In some area, the mains voltages are 110/220 VAC, and in eg Japan, 100 VAC. In these areas, you can replace the power transformer with the 22 VAC secondary version. It is recommended that in order to maximize available power, the 25VA version is used in these cases.

The Nuvotem Talema part numbers are

25VA: 70065K

15VA: 70055K

How to set the output voltage to exactly +-18V

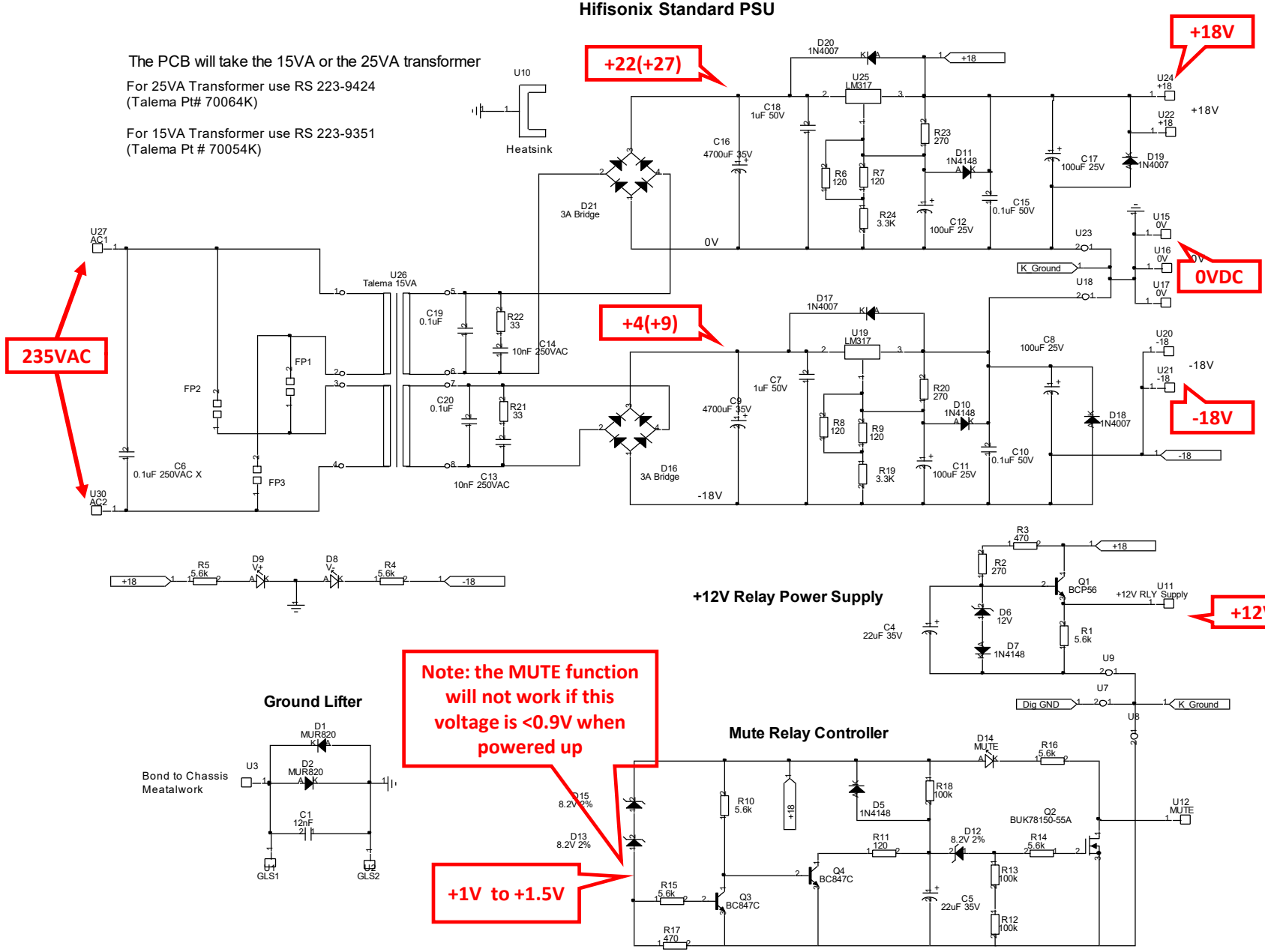
- The Standard PSU Mute function relies on having the output voltage accurately set to +-18V. The LM317 reference voltage spread plus 1% resistor tolerance mean the output can vary by as much as +-1.69V about the nominal 18V (a spread of nearly 3.4V)
- The Standard PSU does not have pots to adjust the output, instead the gain resistors (R24 +(R6//R7) for +18V and R19+(R8//R9)) for -18V are trimmed to get the exact voltage.
- To do this, fit R19 and R24 (3.3k) as shown in the circuit and the component overlay. Short out R6 and R8. If the voltage is within + or – 18V +-200mV then simply leave the as is.
- If not then measure the voltage between the A and O pins on the LM317 and write them down next to the component reference number so you don't mix them up accidently. The voltage must measure between 1.2V and 1.3V with the nominal at 1.25V.
- Click here to download the excel spread sheet to calculate the required gain resistor
- Once you have calculated the total gain setting resistor value, make it up using R6//R7 for the +18V reg and R8//R9 for the -18V reg.
- If the total gain setting resistance is < 3.3k (the standard value in the circuit), choose a lower resistor like 2.7k and make up the remaining required resistance using the other resistors.
- Alternatively, you can solder a 500 to 1k post across R8 and R6 and adjust the output voltage to 18V. Remoce the pot, measure the resistance setting and then make up the required parallel value.

Hifisonix Standard PSU

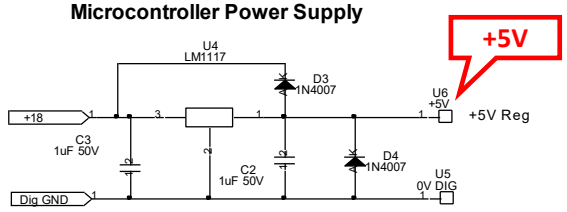
The PCB will take the 15VA or the 25VA transformer

For 25VA Transformer use RS 223-9424
(Talema Pt# 70064K)

For 15VA Transformer use RS 223-9351
(Talema Pt # 70054K)



Microcontroller Power Supply



For the LM1117 above, a 3.3 or 5V output part can be used:-

3.3V part use MSR 863-LM1117MPX-33NOPB

5V part use MSR 863-LM1117MPX-50NOPB

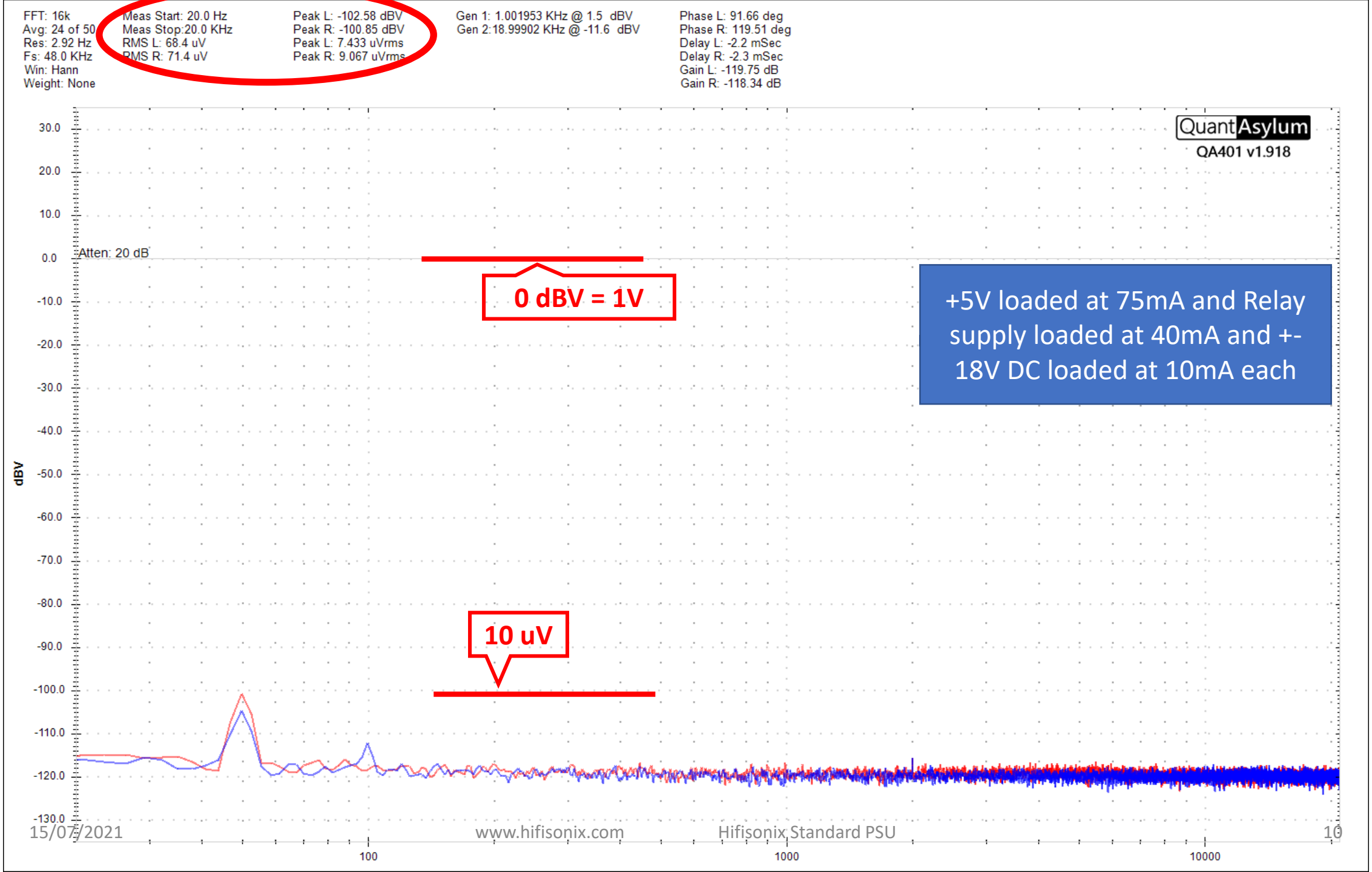
Attention: See slide 7 for details on R6, R7 and R8, R9 and how to adjust the output voltage to exactly +-18 VDC

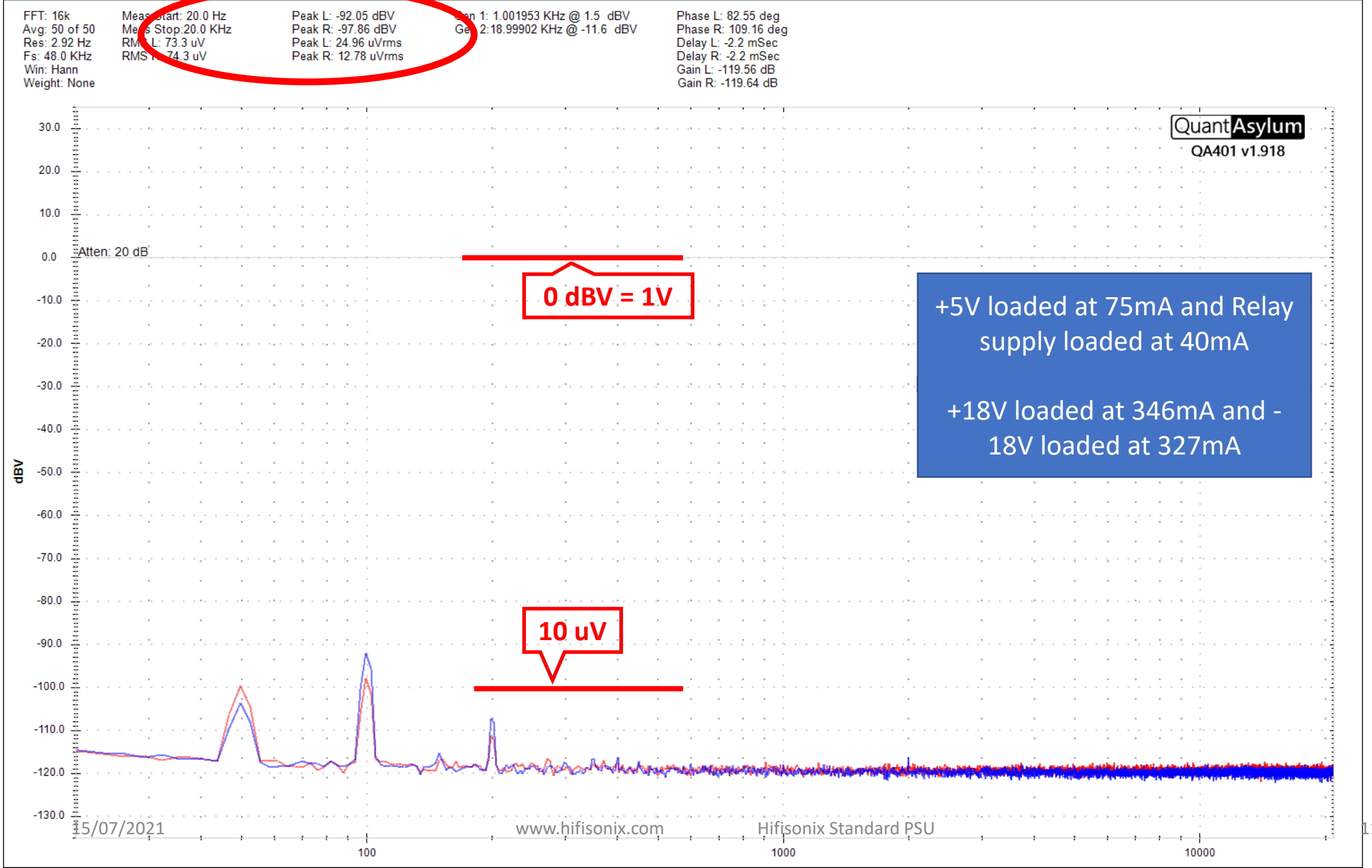
For 240 VAC Operation link FP1 and leave FP2 and FP3 Open.

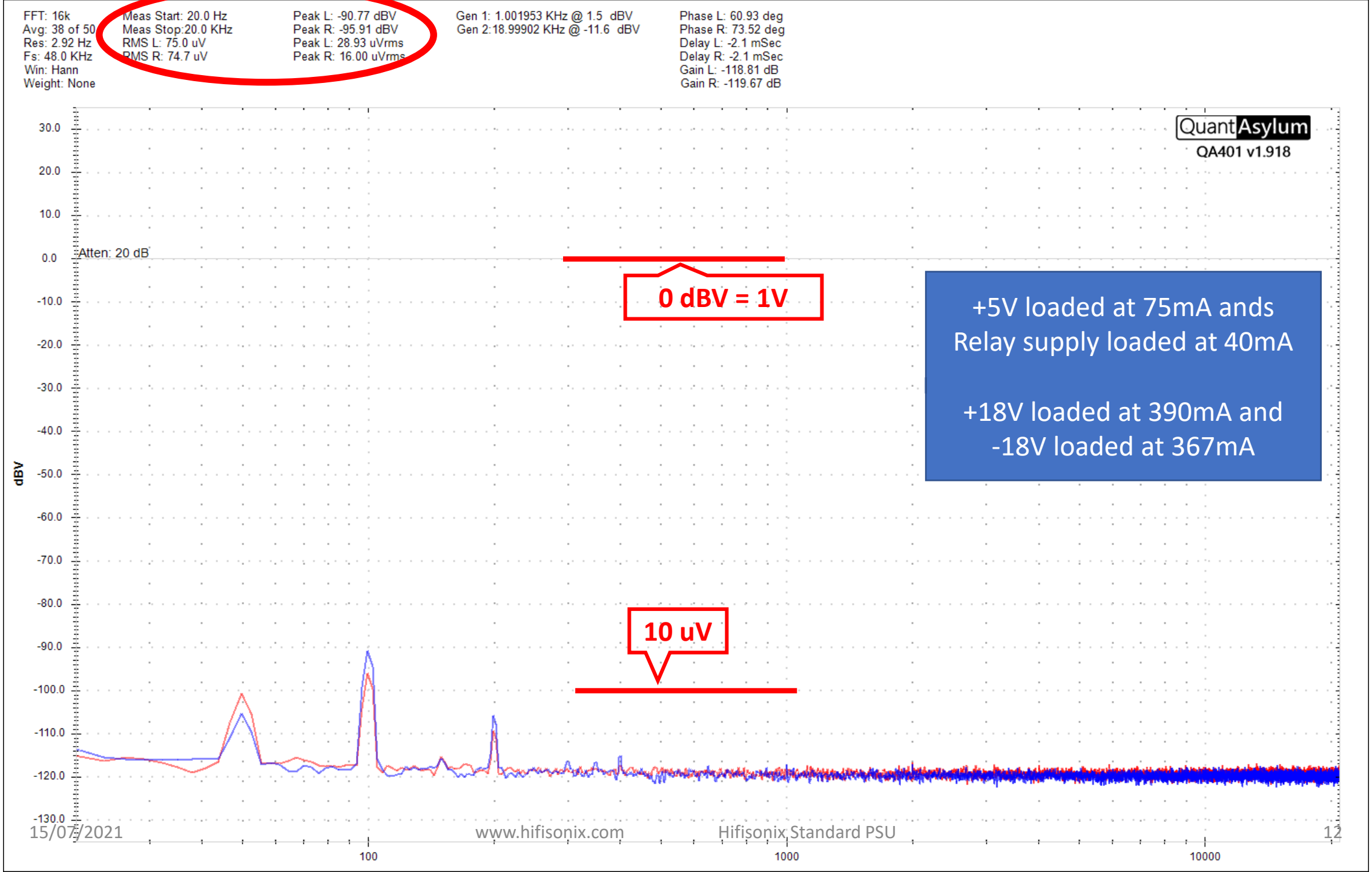
For 120 VAC Operation, leave FP1 Open and link FP2 and FP3

All voltages shown with links in place. Voltages in parenthesis are as measured with the PSU fully loaded. The voltage readings were taken with an AC input voltage of 235V

Measurements

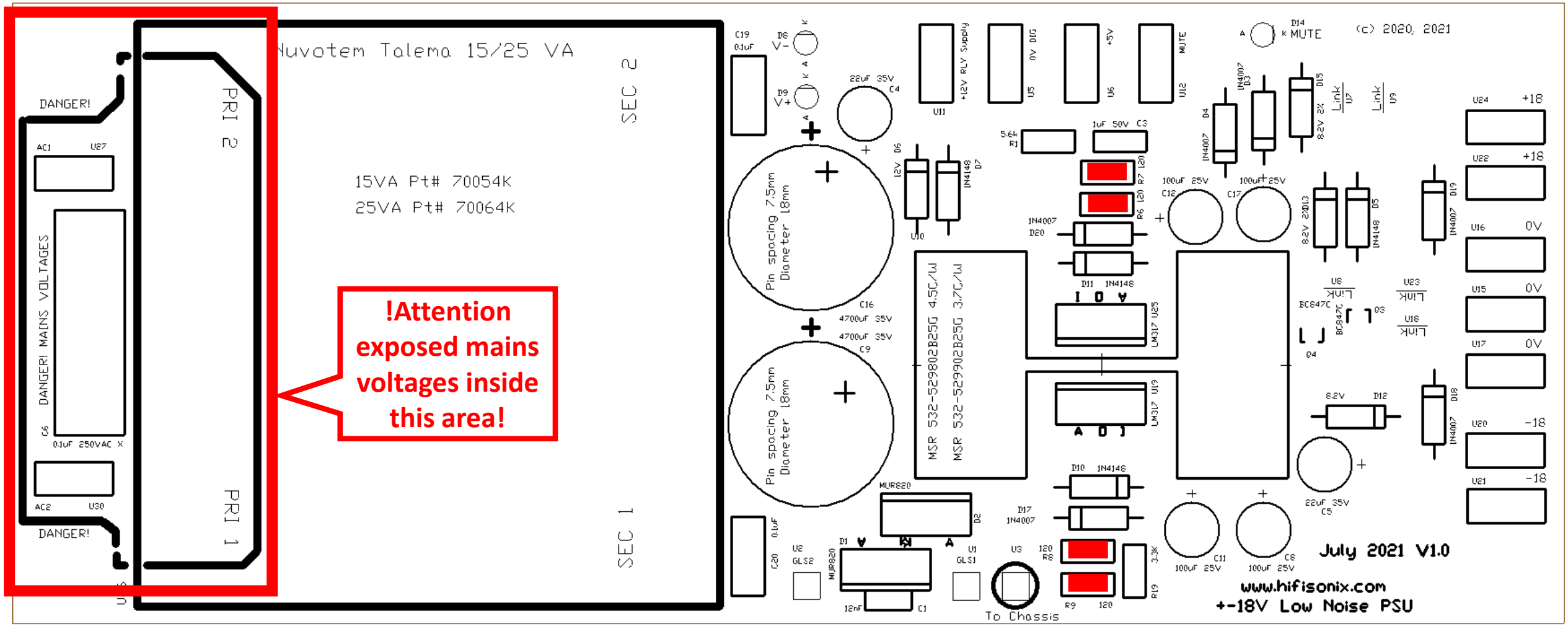

FFT: 16k
Avg: 24 of 50
Res: 2.92 Hz
Fs: 48.0 KHz
Win: Hann
Weight: None
Meas Start: 20.0 Hz
Meas Stop:20.0 KHz
RMS L: 68.4 uV
RMS R: 71.4 uV
Peak L: -102.58 dBV
Peak R: -100.85 dBV
Peak L: 7.433 uVrms
Peak R: 9.067 uVrms
Gen 1: 1.001953 KHz @ 1.5 dBV
Gen 2:18.99902 KHz @ -11.6 dBV
Phase L: 91.66 deg
Phase R: 119.51 deg
Delay L: -2.2 mSec
Delay R: -2.3 mSec
Gain L: -119.75 dB
Gain R: -118.34 dB
QuantAsylum
QA401 v1.918
Atten: 20 dB
0 dBV = 1V
+5V loaded at 75mA and Relay supply loaded at 40mA and +-18V DC loaded at 10mA each
10 uV
dBV
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
100
1000
10000


FFT: 16k
Avg: 50 of 50
Res: 2.92 Hz
Fs: 48.0 KHz
Win: Hann
Weight: None
Meas Start: 20.0 Hz
Meas Stop:20.0 KHz
RMS L: 73.3 uV
RMS R: 74.3 uV
Peak L: -92.05 dBV
Peak R: -97.86 dBV
Peak L: 24.96 uVrms
Peak R: 12.78 uVrms
Gain 1: 1.001953 KHz @ 1.5 dBV
Gain 2:18.99902 KHz @ -11.6 dBV
Phase L: 82.55 deg
Phase R: 109.16 deg
Delay L: -2.2 mSec
Delay R: -2.2 mSec
Gain L: -119.56 dB
Gain R: -119.64 dB
QuantAsylum
QA401 v1.918
Atten: 20 dB
0 dBV = 1V
+5V loaded at 75mA and Relay supply loaded at 40mA
+18V loaded at 346mA and -18V loaded at 327mA
10 uV
dBV
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
100
1000
10000

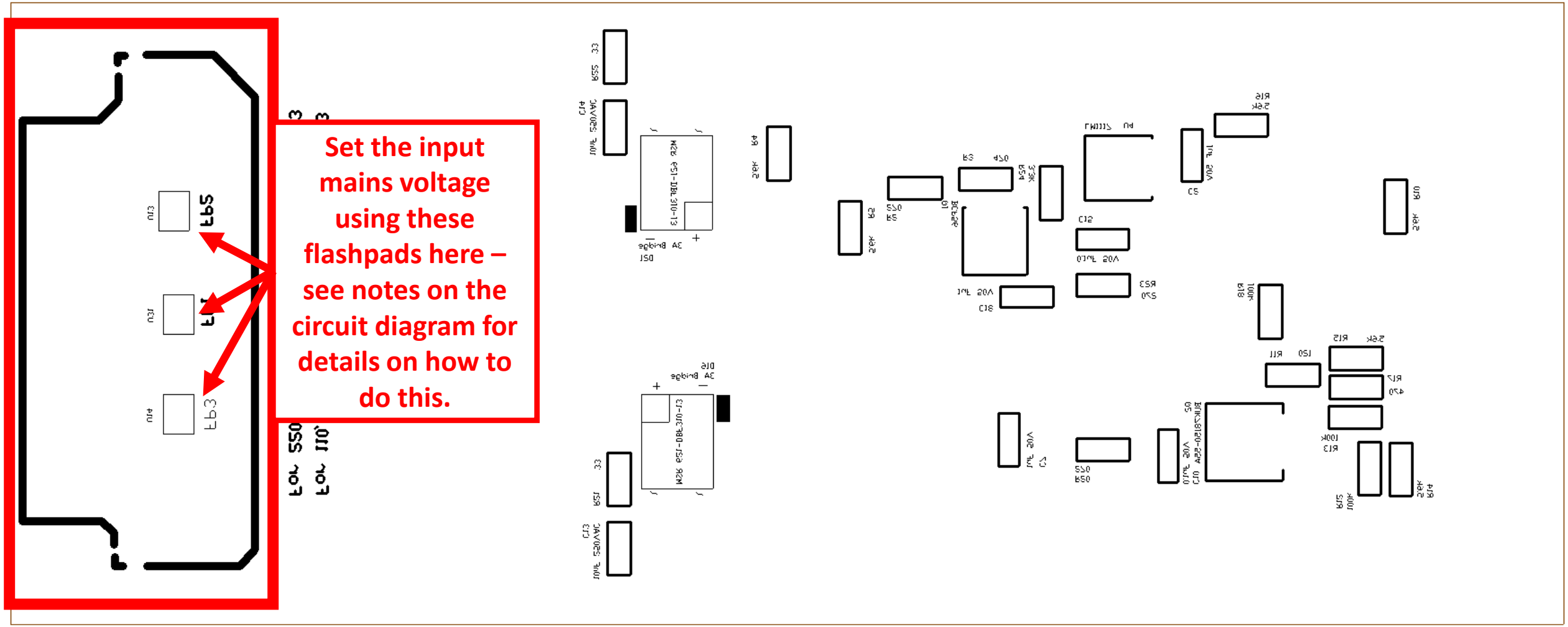

FFT: 16k
Avg: 38 of 50
Res: 2.92 Hz
Fs: 48.0 KHz
Win: Hann
Weight: None
Meas Start: 20.0 Hz
Meas Stop:20.0 KHz
RMS L: 75.0 uV
RMS R: 74.7 uV
Peak L: -90.77 dBV
Peak R: -95.91 dBV
Peak L: 28.93 uVrms
Peak R: 16.00 uVrms
Gen 1: 1.001953 KHz @ 1.5 dBV
Gen 2:18.99902 KHz @ -11.6 dBV
Phase L: 60.93 deg
Phase R: 73.52 deg
Delay L: -2.1 mSec
Delay R: -2.1 mSec
Gain L: -118.81 dB
Gain R: -119.67 dB
QuantAsylum
QA401 v1.918
Atten: 20 dB
0 dBV = 1V
+5V loaded at 75mA ands
Relay supply loaded at 40mA
+18V loaded at 390mA and
-18V loaded at 367mA
10 uV
dBV
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
100
1000
10000

Component Overlay – Top Side

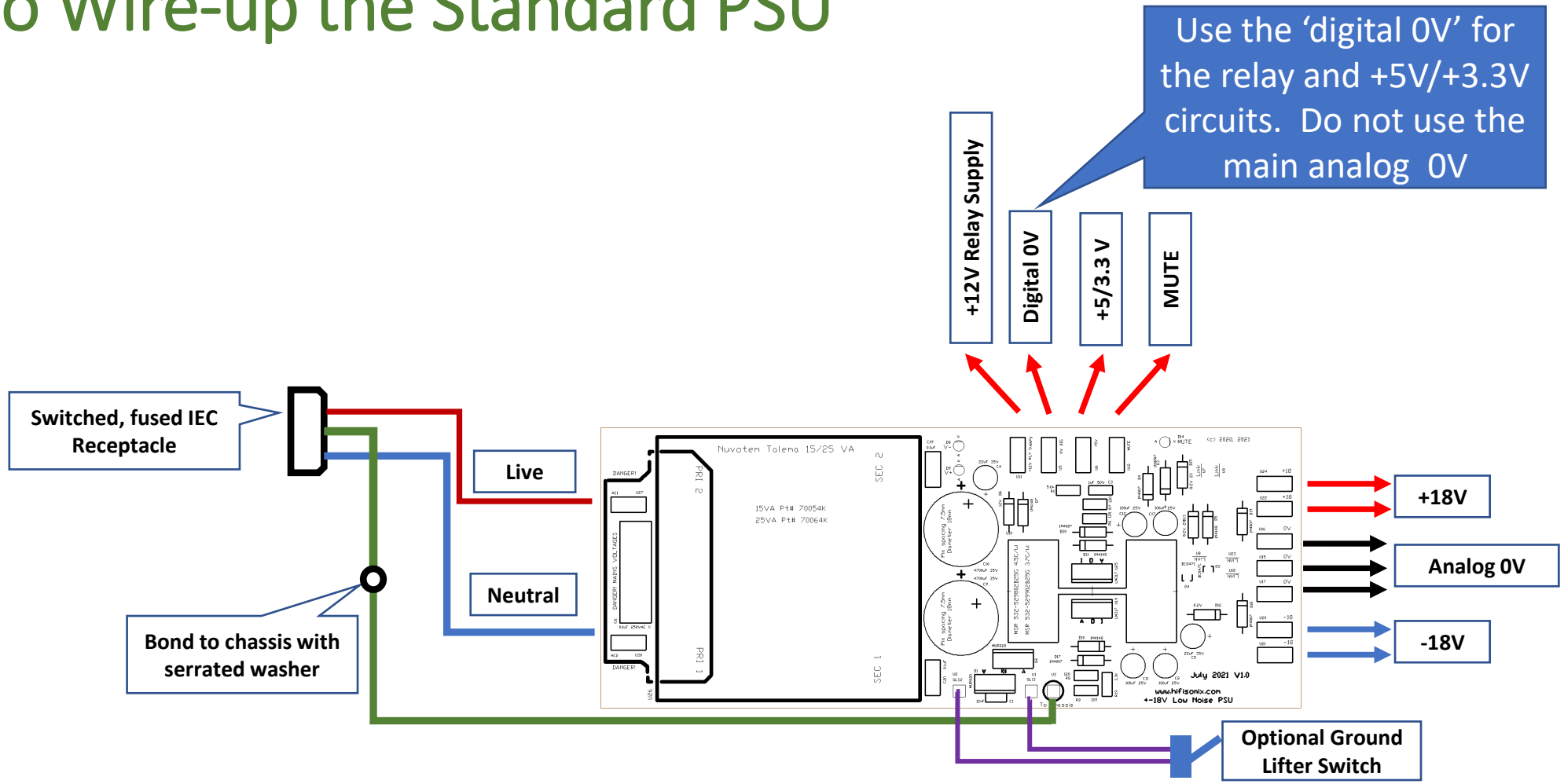
= Location of 120 Ohm resistors used to trim the output voltage to +-18V



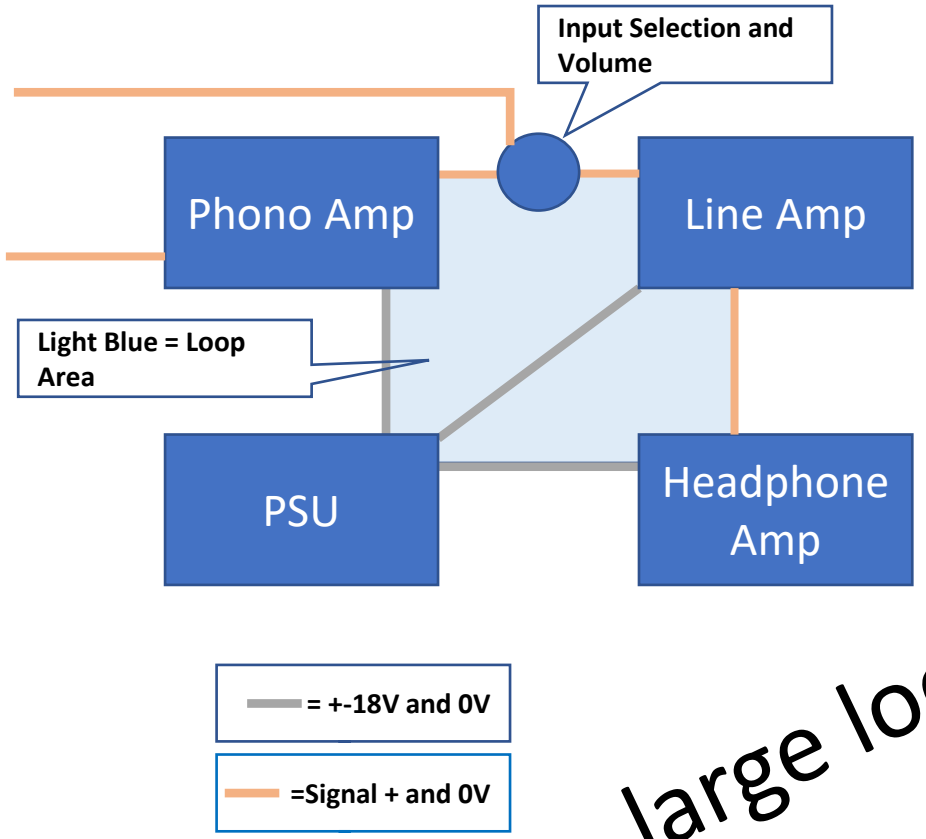
Component Overlay – Bottom Side



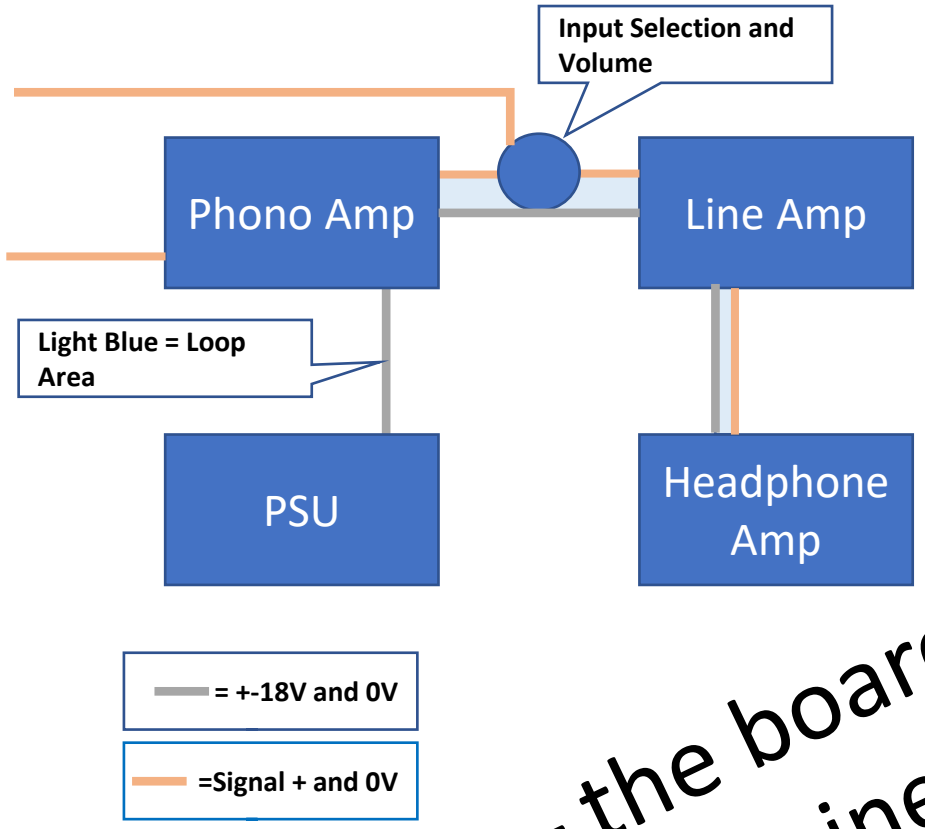
How To Wire-up the Standard PSU



The correct way to wire up modules



Wrong – large loop area



Correct – the boards are daisy chained