# Design Description
# SuperJX Replacement Power Supply

**Author: Guy Wilkinson**

**Date: 15th July 2018**

## Contents

# 1 Abbreviations

| Abbreviation | Definition |
|---|---|
| A | Amps |
| AC | Alternating Current |
| DC | Direct Current |
| DIY | Do It Yourself |
| degC | Degrees Celsius |
| DIY | Do It Yourself |
| ESD | Electro-Static Discharge |
| EPROM | Electrically Programmable Read Only Memory |
| IC | Integrated Circuit |
| IEC | International Electrotechnical Commission |
| IPA | Isopropyl Alcohol |
| IT | Information Technology |
| Hz | Hertz |
| KHz | Kilo Hertz |
| mA | Milli Amperes |
| mH | Milli Henry |
| mV | Milli Volts |
| MLCC | Multi-Layer Ceramic Capacitor |
| N/A | Not Applicable |
| PAT | Portable Appliance Testing |
| PCB | Printed Circuit Board |
| PSU | Power Supply Unit |
| PWM | Pulse Width Modulation |
| R | Resistance (Ohms) |
| RF | Radio Frequency |
| RMS | Root Mean Square |
| SMD | Surface Mount Device |
| uF | Micro Farad |
| V | Volts |
| VFD | Vacuum Fluorescent Display |

# 2 Disclaimer

Users undertaking this DIY project need to have experience in electronics, mains wiring and testing.

With this document, users and installers can make a judgement that the design is fit for purpose and that if they follow the build instructions carefully, then it will result in a secure and safe installation.

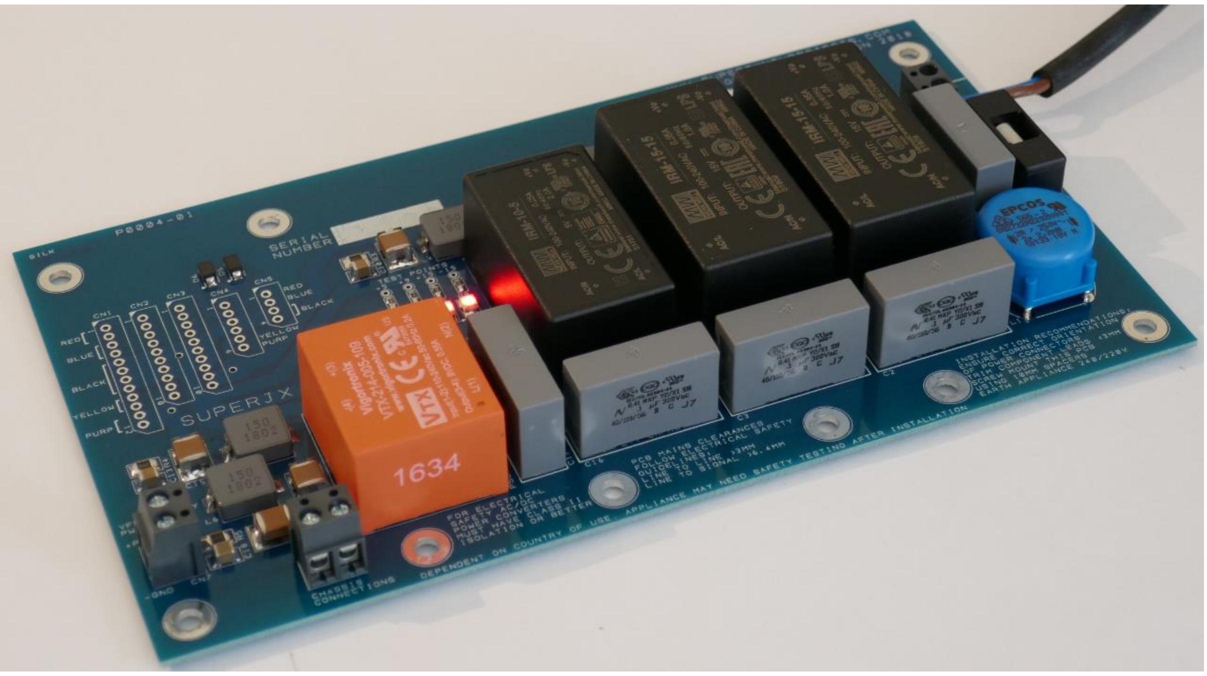
No liability can be undertaken by the author for the design or installation therefore this document is intended to fully describe the design choices, calculations and explain the approach for electrical safety.

In the interests of electrical safety, installers and users are advised to take necessary steps such as Portable Appliance Testing (PAT) and adding a protective earth to the instrument.

# 3 Overview

This is a detailed design description for a DIY project, the replacement SuperJX Power Supply board for the Roland JX10 and MKS70 synthesizers.

This is only offered as a DIY project and fully built modules will not be made available due to the extensive approval costs that would be otherwise required.




**Specifications**

- 195 x 110mm to fit inside MKS70 or JX10
- Single Board solution replaces Transformer and Power Supply Board
- 110-240V 50/60Hz AC operation
- PCB safety clearance: >3mm line-line, >6.4mm line-chassis/signal
- T2A 250V ceramic fuse
- Mains filter
- +5V 1.5A
- +/-15V 0.6A
- +9V 0.55A for VFD display upgrade & PG800
- Short circuit protection
- Power rail indication

**Differences**
It differs slightly in functionality from the Roland design:

- No tracking regulation for +15V and -15V analogue power rails
- +5v logic power is not proportional to the actual voltage on the +15V power rail

It is believed that these differences are circumvented by regulating the output voltage to within 3% for all power rails and the logic power should always be regulated between 4.75 and 5.25 volts in the Roland design.

The design does not meet isolation class II, therefore the instrument has to be wired as UK specification in that an additional protective earth is recommended, see later test data.

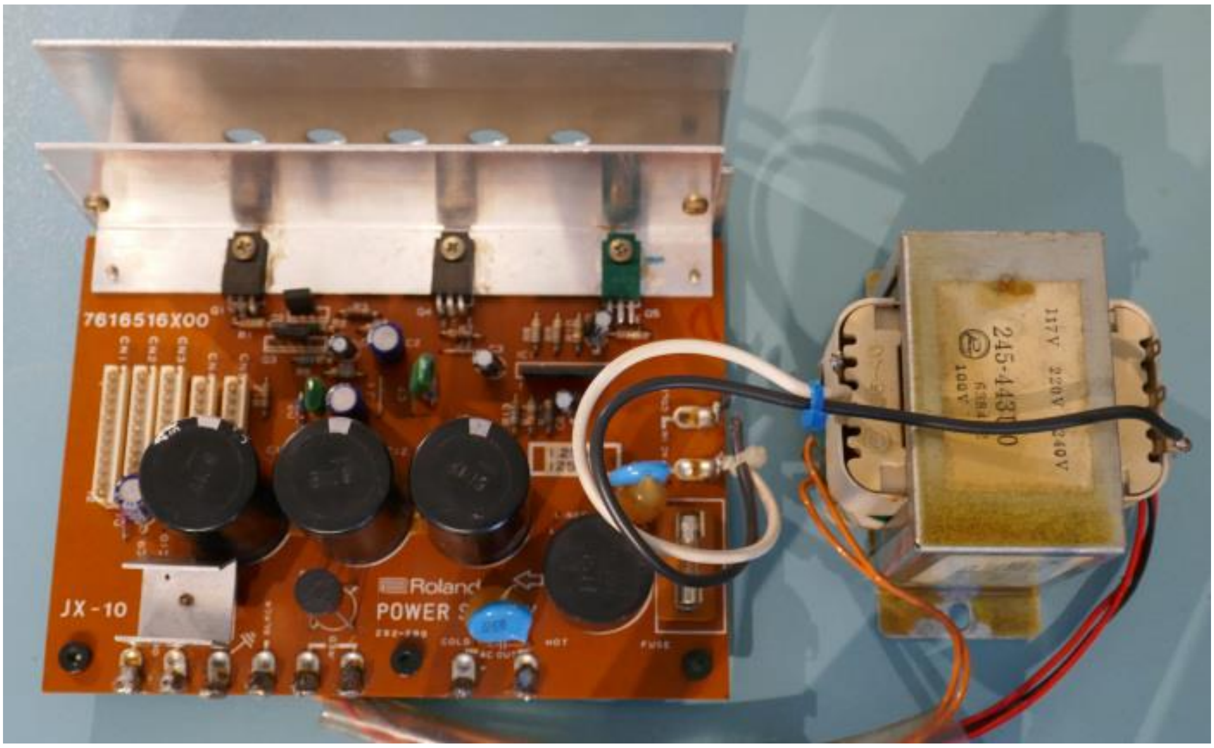
# 4 Background

This design was inspired and sponsored by Peter Connelly because the transformer in his JX10 had failed. The JX10 plays an important part in Peter's professional work, take a look at his website. Many thanks to Peter for providing the funds and requirements into this design to help keep the SuperJX alive.

The board provides a full replacement of the mains filter, transformer and power supply for the JX10 and MKS70, that has no ripple, no dry joint degradation, no limited life capacitors, runs cool and automatically uses any mains voltage from 110VAC to 240VAC. The design is focused around power converters with outboard power filters to remove conversion switching noise, essential for keeping noise away from the audio path.

It is rated at roughly 2/3rd the power consumption needs of a fully upgraded JX10 therefore runs without stress and supports various upgrades without generating excess heat.

Multiple mounting options are provided to replace the power assemblies inside the two different instruments. The MKS70 has the transformer on the left, the JX10 on the right. For example, the JX10 power assemblies are shown below:



# 5 Data Items

The project code for Replacement SuperJX Power Supply is P0004. The version number follows this code by 2 incremental digits. A numeric code suffixes to indicate the type of information.

| Doc / Drawing ID | Description |
|---|---|
| P0004-02-DD | Design Description |
| P0004-02-BFR | Build & Fitting Recommendations |
| P0004-01-SCH | Schematic |
| P0004-02-BOM | Bill of Material |
| P0004-01-DCT | Design Calculations & Test Results |
| P0004-01-TST | Package of oscilloscope traces from tests |
| P0004-01-SIM | Simulation files using LTSpice |

For further reading how the instrument functions electronically, the Roland service manual is available for download from: http://www.synfo.nl/

# 6 Circuit Description

## 6.1 Mains Input

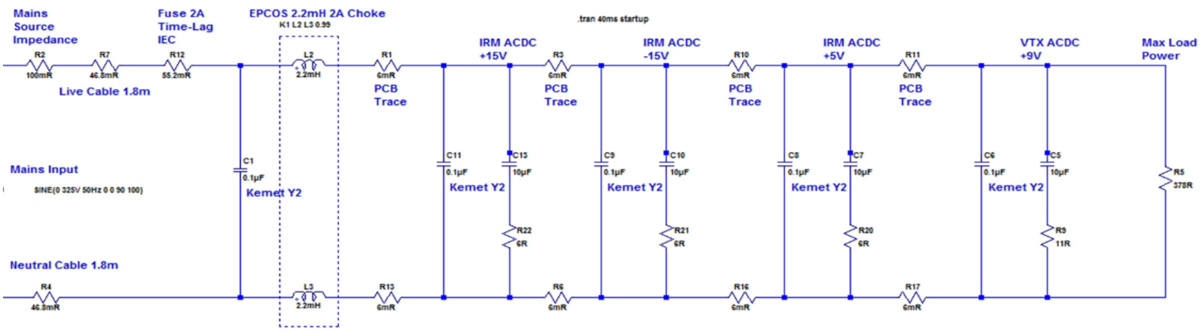
### 6.1.1 Requirements

The table below shows the nominal, worst case and fully loaded current requirements on the mains input, it can be anywhere between 106mA to 657mA depending on instrument configuration and mains voltage:

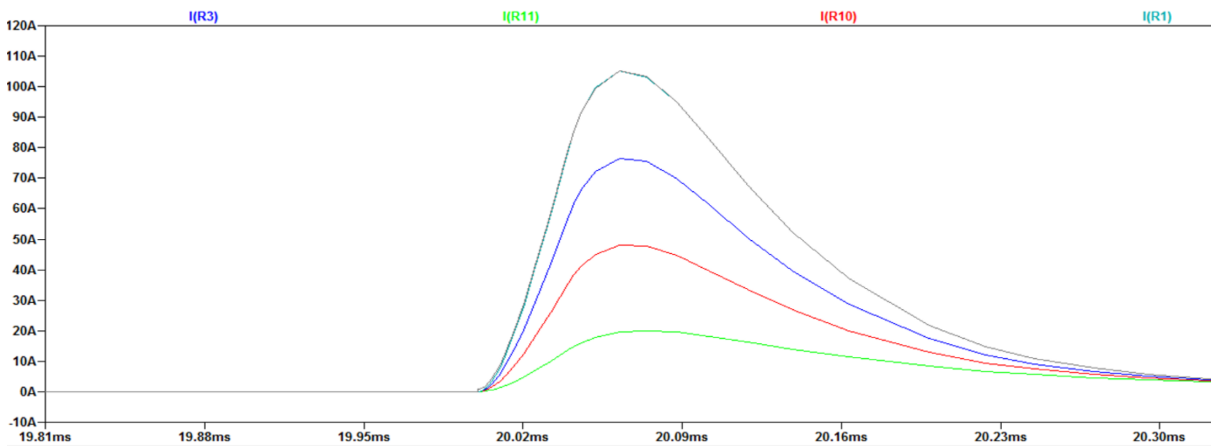
| ACD<br>C<br>Conv | Ou<br>t<br>V | Max<br>Powe<br>r<br>W | No<br>m<br>Eff<br>% | Curren<br>t<br>A | Powe<br>r<br>W | Derate<br>d<br>Power<br>% | Nom<br>Mains<br>Powe<br>r<br>W | Max<br>Mains<br>Powe<br>r<br>W | Mains<br>Curren<br>t<br>@250<br>V<br>A | Mains<br>Curren<br>t<br>@85V<br>A | Max<br>Mains<br>Curren<br>t<br>@85V<br>A | Inrush<br>230VA<br>C 0R<br>Source<br>Resis<br>A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PSU1 | 15 | 15 | 82 | 0.38 | 5.70 | 38.00 | 6.95 | 18.29 | 0.028 | 0.082 | 0.215 | 40 |
| PSU2 | 15 | 15 | 82 | 0.38 | 5.70 | 38.00 | 6.95 | 18.29 | 0.028 | 0.082 | 0.215 | 40 |
| PSU3 | 9 | 5 | 80 | 0.40 | 3.56 | 71.10 | 4.44 | 6.25 | 0.018 | 0.052 | 0.074 | 25 |
| PSU4 | 5 | 10 | 77 | 1.27 | 6.34 | 63.40 | 8.23 | 12.99 | 0.033 | 0.097 | 0.153 | 40 |
| | | | | | | **Totals** | **27** | **56** | **0.106** | **0.313** | **0.657** | **145** |

### 6.1.2 Simulation

A model was created using LTSpice for the power input circuit and is shown below:



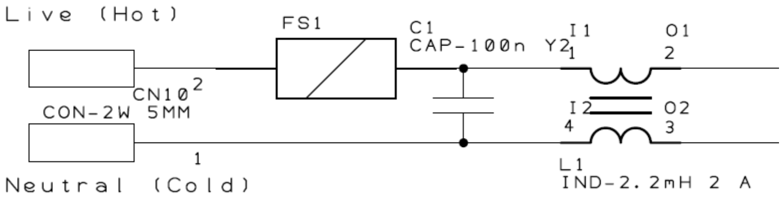

The model represents an equivalent circuit plus most parasitic resistances, this way the fuse parameters were derived. Parameters of particular note were the peak inrush currents experienced by the fuse when the ACDC converters are powered up at a switch on point of 90 or 270 degrees within a mains cycle. The resultant waveform is shown below:




Black trace shows peak current experienced by the fuse, lower traces show current at different points along the power distribution traces finally reaching PSU4 (green).

### 6.1.3 Schematic

The circuit for the mains input is shown below:




### 6.1.4 Connector

A 300VAC rated two pin PCB mount screw terminal brings the power to the PCB that is 10mm away from the edge of the FR4 fibreglass PCB. 10mm is chosen to allow easy cable entry inside the instrument such that minimal bending of the power connections is needed during installation.

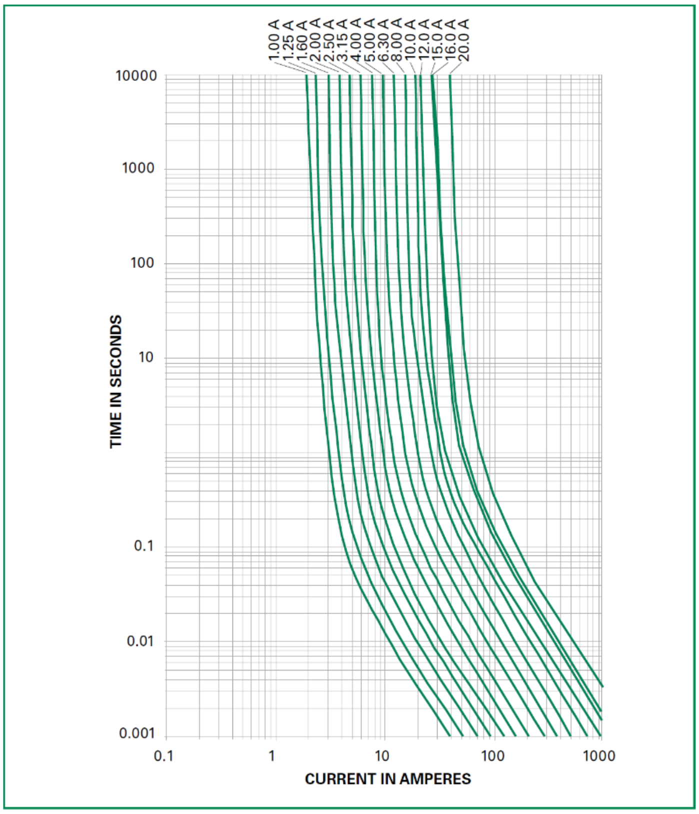
### 6.1.5 Fuse

The fuse holder is a fully enclosed type with insulated cover to prevent electric shock when accidentally touching it if the instrument is open and connected to the mains. The HTC-100M chosen is rated at 6 Amps.

The fuse chosen is a Littelfuse 20x5mm ceramic cartridge type with part number 215.002. Ceramic is chosen rather than glass to prevent possibility of shattering in fault conditions when testing.

Trip current curves are shown below that show the time to heat the fuse and break. Note that the actual inrush energy is much lower than the maximum inrush rating of the fuse due to the fact that the characteristic isn't rectangular.

**T-C Curves for 1A to 20A only**



A 1 Amp time delay fuse can also be used but was found to nuisance trip after a number of cycles of mains input plug being pulled rather than turn off the unit with a switch. A fast blow 2 Amp was tested without issues. See later section for tests conducted.

The fuse calculations are summarised below and a compromise between inrush handling and continuous rating was reached with the 2 Amp time delay fuse chosen so that one fuse could be used for all possible mains input voltages.

| **Fuse Characteristics & Results** | | | **Comment** |
|---|---|---|---|
| Current at max power & min voltage | 0.66 | Amps | At mains input 85V 50/60Hz |
| Min nominal rating @150% | 0.99 | Amps | General guideline to avoid nuisance trips |
| Max nominal rating @200% | 1.31 | Amps | General guideline to avoid nuisance trips |
| Temperature rerating @50 degC | 1.38 | Amps | Max ambient temperature |
| Minimum fuse rating chosen | 1.00 | Amps | Nearest preferred value from 150% |
| Maximum fuse rating chosen | 2.00 | Amps | Nearest preferred value from 200% |
| Fuse Type | Time Delay | | |
| Approval standard | IEC60127-2 | | |
| Manufacturer | Littelfuse | | |
| Part Number - 1A | 0215001.MXP | | |
| Handling rating at 250us extrapolated - 1Amp | 60 | Amps | Pessimistic evaluation |
| Part Number - 2A | 0215002.MXP | | |
| Handling rating at 250us extrapolated - 2Amp | 105 | Amps | Pessimistic evaluation |
| **PCB & Critical Components** | | | |
| Required PCB handling capacity @150% | 3.00 | Amps | |
| Continuous PCB capacity 3mm 1oz | 5.20 | Amps | Continuous rating with 10 degree rise |
| Max fuse rating for 3mm PCB traces | 3.47 | Amps | |
| Continuous rating for CM choke | 2 | Amps | Continuous rating, peak unknown |
| **Simulation Results 325VDC - 230VAC RMS Turn on @ 90 deg phase** | | | |
| Filter network peak inrush current | 14 | Amps 150uS | |
| Peak inrush current ACDC & Filter | 103 | Amps 80uS | Lower than 140 Amps due to resistance |
| Average inrush current over 280uS | 60 | Amps | |
| **Conclusions** | | | |
| Fuse chosen meets requirements for inrush that is in practice much smaller in energy. | | | |
| T1A or T2A IEC fuse is rated low enough to protect PCB & choke from overload. T2A avoids potential nuisance trips. | | | |

PCB version P0004-01 is marked with “1 Amp antisurge 250V” but should be 2 Amp and is corrected in P0004-02 onwards. Note that the 1A fuse is acceptable for USA 110V.

### 6.1.6 Filter

A class Y safety capacitor C1 is used to suppress transients arriving on the line between live and neutral. Class Y was chosen over class X to prevent nuisance, so that it goes open circuit if it fails and doesn’t become an issue apart from increased RF emissions that are unlikely be noticed and should a transient ever occur then it will simply blow the fuse and stop working.

The common mode filter configuration from the original Roland design is followed whereby no connection is made to chassis. This has a disadvantage that more RF interference can conduct out of the appliance but the advantage is that there is much reduced leakage current from mains line to chassis thus improving safety.

A 2.2mH 2Amp type was chosen based on continuous fuse rating, price and availability. The high inductance/resistance also plays a significant role in reducing the peak inrush current value at switch on. Additionally, 2.2mH should offer a great deal of attenuation.

## 6.2 AC/DC Power Converters

### 6.2.1 Requirements

There are four power rails required for the SuperJX and the requirements of the instrument for the different upgraded configurations are shown in the table below:

| Power Rail V | Standard & PG800 mA | Power On Peak Current mA | Enhanced VFD mA | PWM mA | Enhanced VFD & PWM mA | AC/DC Max @50C mA | Worst Case mA | Max Rating % | Best Case mA | Min Rating % |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 220 | 600 | 220 | 380 | 380 | 1000 | 600 | 60 | 220 | 22 |
| -15 | 220 | 600 | 220 | 380 | 380 | 1000 | 600 | 60 | 220 | 22 |
| 5 | 1268 | 1268 | 1023 | 703 | 823 | 2000 | 1268 | 63 | 703 | 35 |
| 9 | 200 | 200 | 395 | 200 | 395 | 550 | 395 | 72 | 200 | 36 |
| Enhanced Graphic VFD option assumes CMOS Voice ROMs | | | | | | | | | | |

| Electronic Feature | mA |
|---|---|
| PG800 | 80 |
| Enhanced Graphic VFD | 315 |
| Roland VFD | 200 |
| NMOS ROMS | 225 |
| CMOS ROMS | 60 |
| NMOS Voice CPUs | 320 |
| CMOS Voice CPUs | 120 |

### 6.2.2 Choice

The following regulated power converters were chosen for the design based on the following, in priority order:

1. Safety approvals & Isolation Class
2. Price
3. Reputation
4. Size

Specifications were checked to ensure a regulated type was chosen, unregulated is often offered at low cost or smaller size.

Mean Well are the most cost effective when buying in low volume and was best choice for standard voltages.

Vigortronix was chosen for the 9V 5 Watt output converter for VFD & PG800 power based on availability. This rail could be supplied with 12V, however with 12V, losses and heating would be increased in the Roland VFD FIP coil and PG800 regulator that could lead to premature failure.

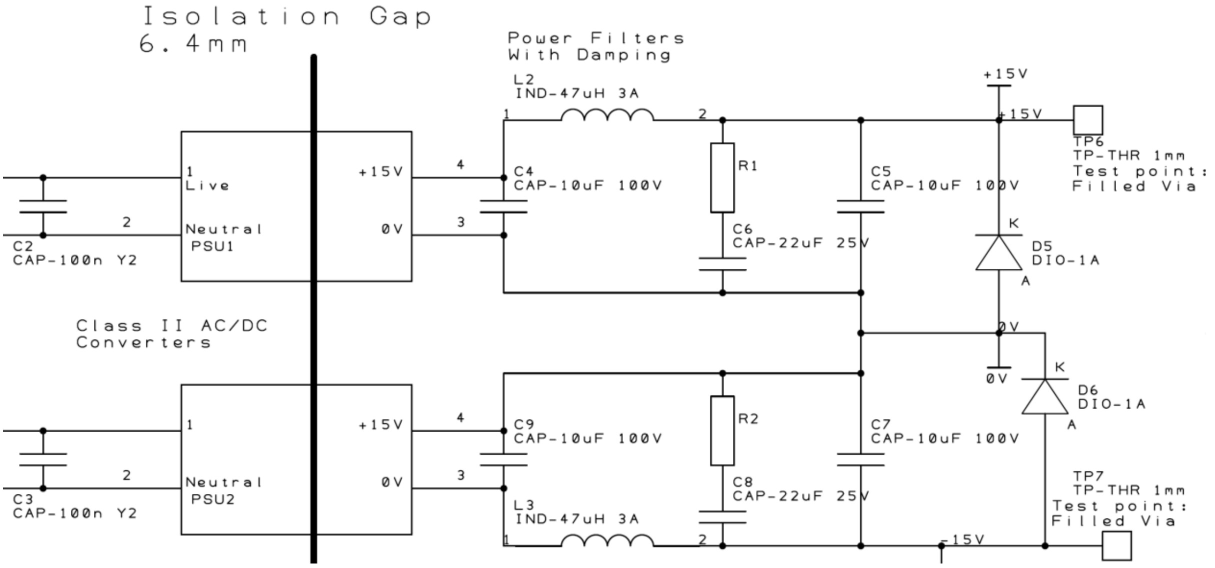
Normally, the “+7V Unreg” rail is on average 10V with +/-1V ripple. When using a regulated supply, 9V is the best choice for the instrument and is also the voltage that gives the best efficiency and emissions for the converter in the graphic VFD upgrade.

| Reference | Voltage | Wattage | Manufacturer | Part Number | Farnell |
|---|---|---|---|---|---|
| PSU1 | 5 | 10W | Mean Well | IRM-10-5 | 2815498 |
| PSU2 & 3 | 15 | 15W | Mean Well | IRM-15-15 | 2815500 |
| PSU4 | 9 | 5W | Vigortronix | VTX-214-005-109 | 2401043 |

Note that these converters are commercial grade and low cost so they have important limitations such as high input to output capacitance and high inrush current as discussed in this document.

### 6.2.3 15V Power

A circuit for the +15V & -15V power rails is shown below:




For the 15V power rails a Mean Well IRM15-15 AC-DC converter is used and the specification can be found at the link below:

[http://www.meanwell-bg.com/files/Models/IRM-15-spec.pdf](http://www.meanwell-bg.com/files/Models/IRM-15-spec.pdf)

Important characteristics are

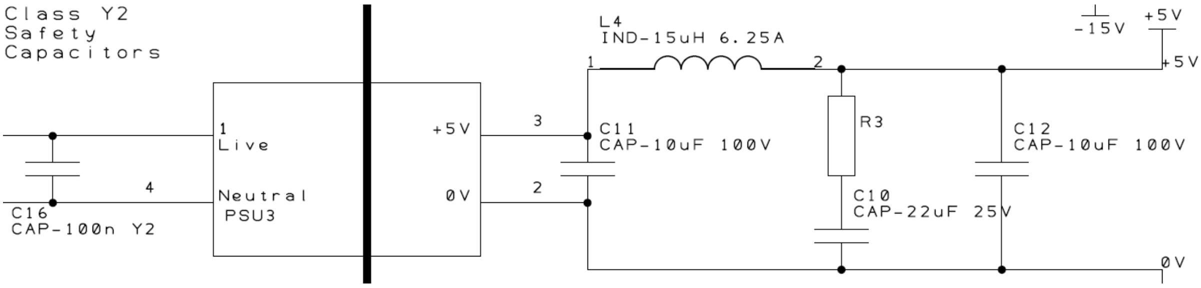
- AC input from 85VAC to 264VAC
- 15 Watts of power: 15V @ 1Amp
- Approved safety standards: UL60950-1 & TUV EN60950-1
- Isolation is Class II (Double Isolation – no single failure can cause an electric shock).

The mains input has a class Y2 safety capacitor that works together with the common mode filter on the mains input to attenuate noise conducting out of the mains supply. The capacitor also provides a small reserve of current for high frequency noise arriving from the “chopping” action of the converter, that could otherwise conduct into neighbouring converters possibly disturbing their function.

The power filter on the output is described in a later section.

### 6.2.4 5V Power

A circuit for the +5V power rail is shown below:




For the 5V power rails a Mean Well IRM10-15 AC-DC converter is used and the specification can be found at the link below:

http://www.meanwell-bg.com/files/Models/IRM-10-spec.pdf

Important characteristics are

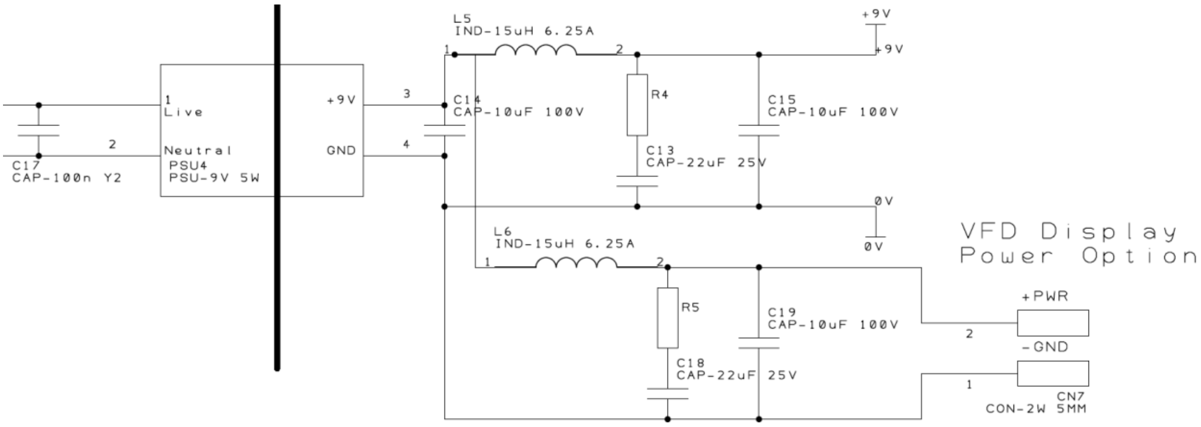
- AC input from 85VAC to 264VAC
- 10 Watts of power: 5V @ 2Amp
- Approved safety standards: UL60950-1 & TUV EN60950-1
- Isolation is Class II (Double Isolation – no single failure can cause an electric shock).

The mains input has a class Y2 safety capacitor that works together with the common mode filter on the mains input to attenuate noise conducting out of the mains supply. The capacitor also provides a reserve of current for the “chopping” action of the converter that would otherwise conduct into neighbouring converters possibly disturbing the function.

The power filter on the output is described in a later section.

### 6.2.5 9V Power

A circuit for the +9V power rail is shown below:




For the 9V power rails a Vigortronix VTX-214-005-109 AC-DC converter is used and the specification can be found at the link below:

http://www.vigortronix.com/5WattACDCPCBPowerModule.aspx

Important characteristics are

- AC input from 90VAC to 264VAC
- 5 Watts of power: 9V @ 0.555Amp
- Approved safety standards: EN60950-1, EN61558-1, EN61558-2-6, EN61558-2-17, TUV
- Isolation is Class II (Double Isolation – no single failure can cause an electric shock).

The mains input has a class Y2 safety capacitor that works together with the common mode filter on the mains input to attenuate noise conducting out of the mains supply. The capacitor also provides a reserve of current for the “chopping” action of the converter that would otherwise conduct into neighbouring converters possibly disturbing the function.

The power filter configuration on the output is described in a later section. There are two filters employed, one for the instrument & PG800 power and another for the Enhanced VFD display option. Although considered over engineered, using a separate filter for the VFD prevents coupling of noise generated by the VFD into the PG800 power that might radiate into the audio circuitry and wiring.

## 6.3 Earth Leakage

### 6.3.1 Requirements

Requirements for class I & II appliances are shown in the table below:

| PAT Leakage Limits | | |
|---|---|---|
| **Class** | **Appliance Type** | **Max Leakage mA** |
| I | Handheld & Portable | 0.75 |
| I | IT, Moveable, Stationary, Fixed | 3.5 |
| I | Heating | 0.75/KW |
| II | All | 0.25 |

Class I appliances require a protective earth. Class II appliances do not have a protective earth.

The Roland SuperJX instruments have their ground reference connected to the output jacks and metal casing so careful consideration needs to be given to leakage from AC mains input to the enclosure ground.

Note that the instrument could be used with headphones so any leakage current could pass directly through the human body when switched on.

### 6.3.2 Design

ACDC converters all leak AC current from their input to output mostly due to the capacitance of the output transformer or when a capacitor is employed to feedback output to input.

The ACDC converters chosen are no exception and the table below shows the maximum leakage current at 240VAC from published data:

| Ref | Type | Theoretical max leakage @ 240VAC mA | Theoretical max leakage @ 110VAC mA |
|---|---|---|---|
| PSU1 | IRM15-15 | 0.75 | 0.34 |
| PSU2 | IRM15-15 | 0.75 | 0.34 |
| PSU3 | IRM10-5 | 0.75 | 0.34 |
| PSU4 | VTX-214-005-109 | 0.3 | 0.14 |
| | **Total** | **2.55** | **1.17** |

The theoretical maximum shown in the table above is 2.55mA and therefore a modified Roland SuperJX comes under “Class I - IT, Moveable, Stationary, Fixed”.

The Roland SuperJX instrument with the replacement power supply is therefore deemed class I and has to have a protective earth fitted.

The test results on a sample show a much lower figure, see later section.

## 6.4 DC Output Filters

### 6.4.1 Requirements

The power converters regulate to within 2.5% however they impart 200mV of 100KHz “ripple” that is a mix of different harmonic frequencies. Converters need ripple in order to perform the conversion by reading back the voltage seeing it change and triggering the next PWM cycle to charge the output inductor

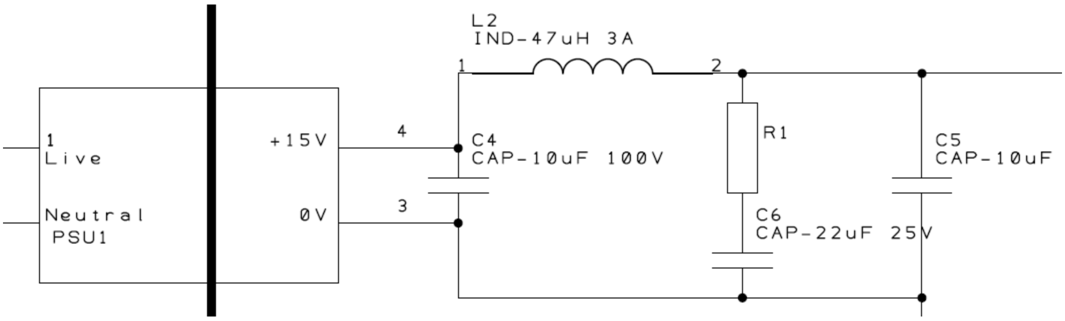
Many commercial applications are not troubled by the noise generated however the analogue audio in the SuperJX relies on a very high quality, low noise, linear regulator arrangement that has a low output impedance (hence why improving the rectifier capacitors has no effect).

Not only could the SuperJX be affected by the noise but the SuperJX could affect the regulation of the converter because the 1986 design has poor PCB layout and decoupling. Conducted noise coming from the SuperJX circuitry could disturb the conversion in such a way that ripple is increased or worse, the regulated voltage is affected.

Noise from the instrument PCBs, can conduct into the mains supply, hence why the Roland MKS70 has additional ferrite bead based filtering between the Power Supply Board and the transformer. The filter therefore plays a double edged role in keeping everything under control.

### 6.4.2 Arrangement

A power filter arrangement was designed and is shown below:




Careful layout and choice of SMD components are essential for it to function well. Capacitors chosen are surface mount Ceramic MLCC that have extremely low impedance. The design of this filter on the PCB is such that all components and traces connect without using vias to keep any parasitic resistance and current loop areas to an absolute minimum.

Practically, the best results were obtained by using 100V rated capacitors. When using 25V higher ripple was evident due to the effects of compression that ceramic capacitors suffer from (change in capacitance with voltage). The bill of materials suggests an alternative lower cost 10uF 25V capacitor should the 100V be deemed too expensive or not necessary.

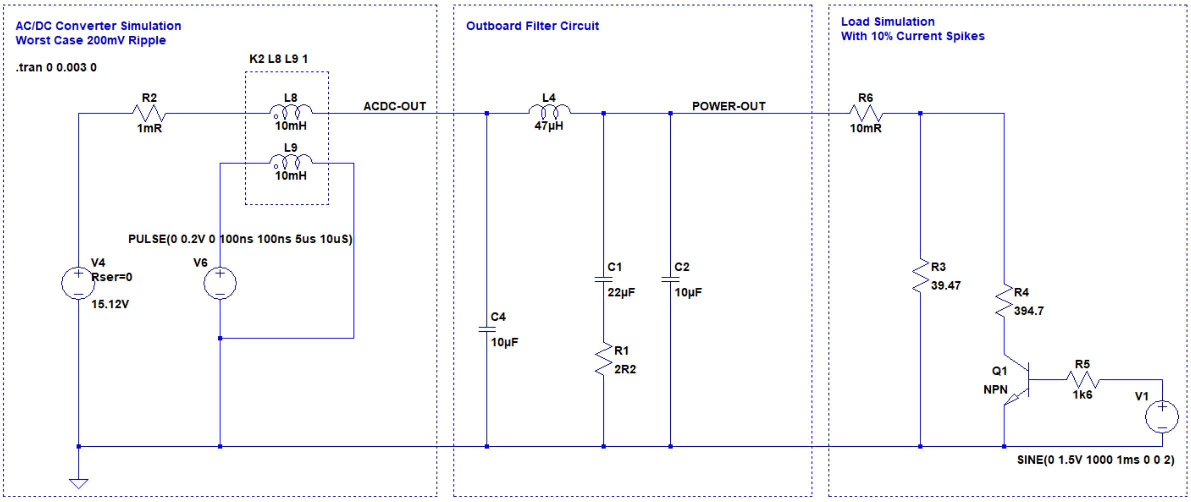
The output of the converter has C4 to decouple and clean up any high frequency noise from the converter. The capacitor must be kept low so as not to disturb the converters function but high enough to take out noise. L2 and C5 provide attenuation of the ripple, the value is chosen so that the cut off point is well below the 100KHz switching frequency but not so high in value such that the series resistance doesn’t cause a large voltage drop/heating under maximum load.

A damping network is added using R1 and C6, this is necessary so that current spikes don’t cause L2 and C5 to resonate and create new harmonics.

### 6.4.3 Simulation

#### 6.4.3.1 Design

The collection of component values required a careful balancing act and was developed using a simulation tool LTSpice.




The filter is shown in the middle section of the figure, a "worst case" ripple simulation of the converter is on the left and a simulation of the load on the right. For the load simulation a small extra circuit is added to inject current spikes that are to simulate abrupt load variation 10% of max rating to allow easy checking of ringing/damping network.

#### 6.4.3.2 Results

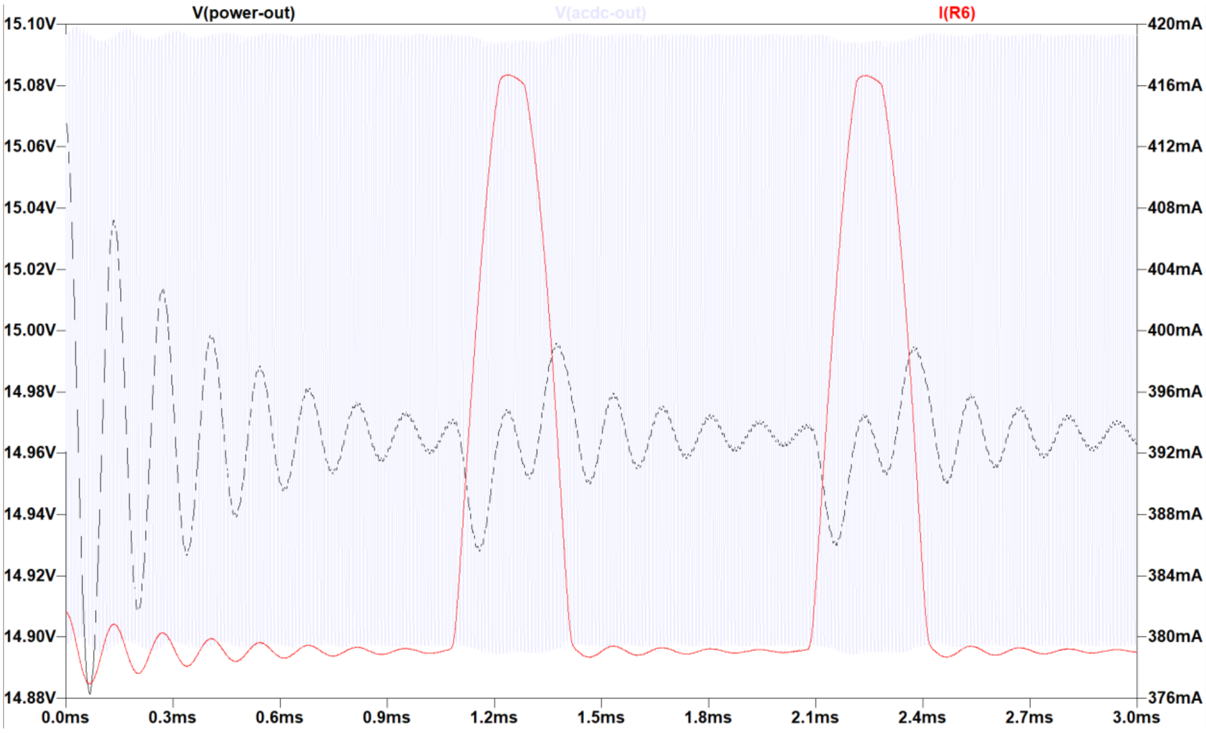
The output of this filter is shown below:


The grey trace is the 100KHz ripple from the converter, the black trace is the output of the filter and red is the load current. The 200mV of ripple is reduced to 1.8mV and the current spikes result in only

43mV of disturbance. The effects of inductor resistance indicate a theoretical drop of 36mV at maximum load.

This is deemed as good enough performance for such a simple configuration for a circuit running from 15V supply.

To demonstrate the actions of the damping network and show its effects, the figure below shows the performance when the damping is removed:




It shows that the damping network is worth adding to the design as it provides additional stability with complex load variation.

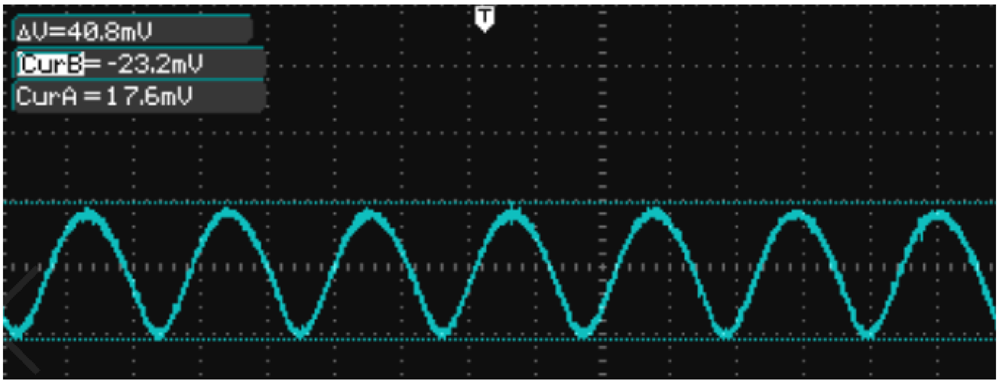
The filters are replicated on all output stages and give the following results:

| Reference | Voltage | Power Rail V | Worst Case mA | Steady State Ripple mV | 10% Load Variation Ripple mV | Voltage Drop mV |
|---|---|---|---|---|---|---|
| PSU2 & 3 | 15 | 15 | 380 | 2 | 43 | 36 |
| PSU1 | 5 | 5 | 1268 | 3 | 17 | 28 |
| PSU4 | 9 | 9 | 395 | 4 | 17 | 14 |

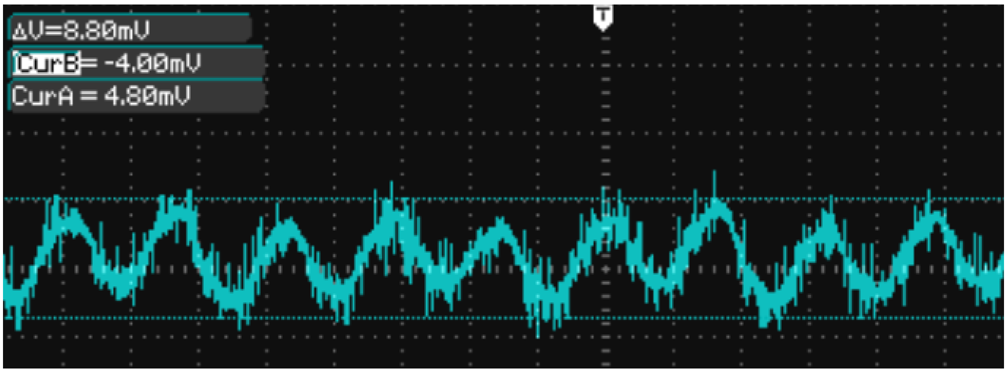
These results show that the design using switching converters and filters will have minimal impact on the SuperJX performance.

#### 6.4.3.3 Real World Measurements

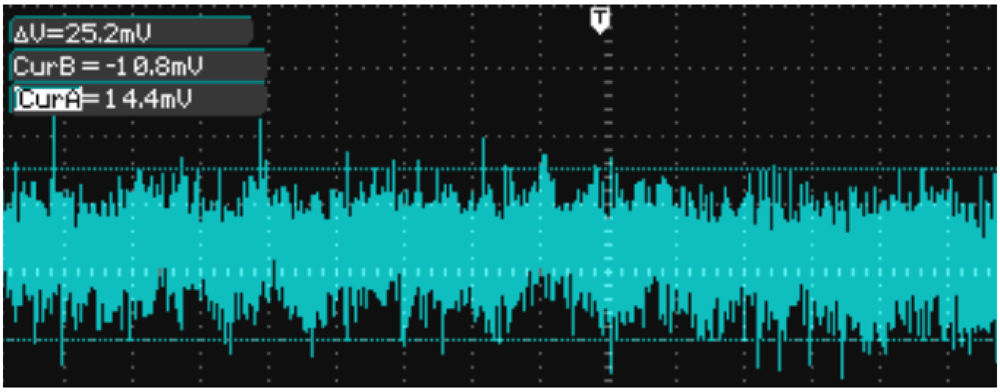
In practice the output ripple with the 10uF capacitor in place resulted in 100KHz 40.8mV on the converter output.




Attenuation by the filter to immeasurable ripple with a basic resistive load is shown below:




Connection to the SuperJX was a different matter, the conducted emissions and complex current demands from all of the PCBs demonstrated the difficulty in keeping the power rails under control with old technology:




The ripple measured was a very low 25.2mV with a primary 1000Hz harmonic and was not seen on the power converter output terminals. Changing capacitance or adjusting damping would not remove this characteristic therefore the PCBs being powered rely on the local 100uF decoupling capacitors.

Considering the several meters of cable running through the instrument delivering power to several large 2 sided PCBs, it is better than could be hoped for.

## 6.5 PCB Layout

### 6.5.1 Design Rules

In this design, rules have been followed for the PCB layout that considerably exceed normal good practice for mains powered equipment.

- >3mm Line to Line clearance
- >6.4mm Line to chassis or signal clearance
- >6.4mm Line to fixing point
- >6.4mm Line to edge of PCB to allow PCB edge to be installed against metalwork
- Neutral (marked “Cold” on Roland Service manual wiring) traces run on the bottom side copper that is closest to chassis when installed.
- Live (marked “Hot” on Roland Service manual wiring) traces run on the top side copper that is mostly underneath insulated power components and assemblies. Any exposed traces are inaccessible by top side handling due to the height of the components.
- Mains line traces are 3mm in width wherever possible to ensure that the fuse to reacts correctly when handling momentary fault currents that could be caused by faulty component or AC/DC converter.
- All components connected to the mains have insulated bodies.

The above rules minimise exposure of live connections and traces to mostly the top side although through hole connection points to each component/assembly are exposed on both sides of the PCB.

The PCB must be spaced away from any metal surface to a distance of 10mm so appropriate spacers are recommended. Roland used 10mm spacing on their original design. To meet the minimum 6.4mm gap between line and chassis, it is recommended that maximum lead length protrusion is no more than 2mm from the underside of the PCB resulting in 8mm gap that allows for any further slight surface panel flexing.

### 6.5.2 Power Traces

All power traces both AC or DC are 3mm in width, if allowing for a 10 degree C rise, then they are capable of carrying 5.2 Amps. This parameter is particularly important in respect of the mains fuse ratings both on PCB and external power plug.

For DC power rails the trace width minimises voltage drops.

| ANSI PCB TRACE WIDTH CALCULATOR | | | | | |
|---|---|---|---|---|---|
| Input Data | | | Results Data | | |
| | | | | External Traces | |
| Field | Value | Units | Trace Data | Value | Units |
| Current (max. 35A) | 5.2 | Amps | Required Trace Width | 2.99 | mm |
| Temperature Rise (max. 100°C) | 10 | °C | Cross-section Area | 0.1 | mm² |
| Cu thickness | 1 | oz/ft² | Resistance | 0.03 | Ω Ohms |
| Ambient Temperature | 50 | °C | Voltage Drop | 0.15 | Volts |
| Conductor Length | 150 | mm | Loss | 0.79 | Watts |
| Peak Voltage | 250 | Volts | Required Track Clearance | 73 | mil |

# 7 Electrical Safety

This section describes the original Roland design followed by recommendations when installing the new Power Supply.

Electrical safety is an important consideration when undertaking rewiring of mains. It is vital that connections are secure, insulated and clear of any metalwork.

## 7.1 Original Roland Design Considerations

### 7.1.1 Power Supply Arrangement

It is important to note that the 1986 design of the original Roland Power Supply scheme classed insulation in different ways that were country specific as per the table below:

| Mains Voltage | Country | Mains Inlet | Earthed | Insulation Class II Mark |
|---|---|---|---|---|
| 105 | Japan | 2 pin | No | No |
| 110 | USA | 2 pin | No | No |
| 220 | Europe | 2 pin | No | Yes |
| 240 | UK | 3 pin IEC | Yes | No |

Although the designs are almost identical apart from fuse rating and mains inlet type, the design was deemed not suitable to meet class II ("double insulated") for UK at 240V. At the time, the rules may have been less stringent in Europe.

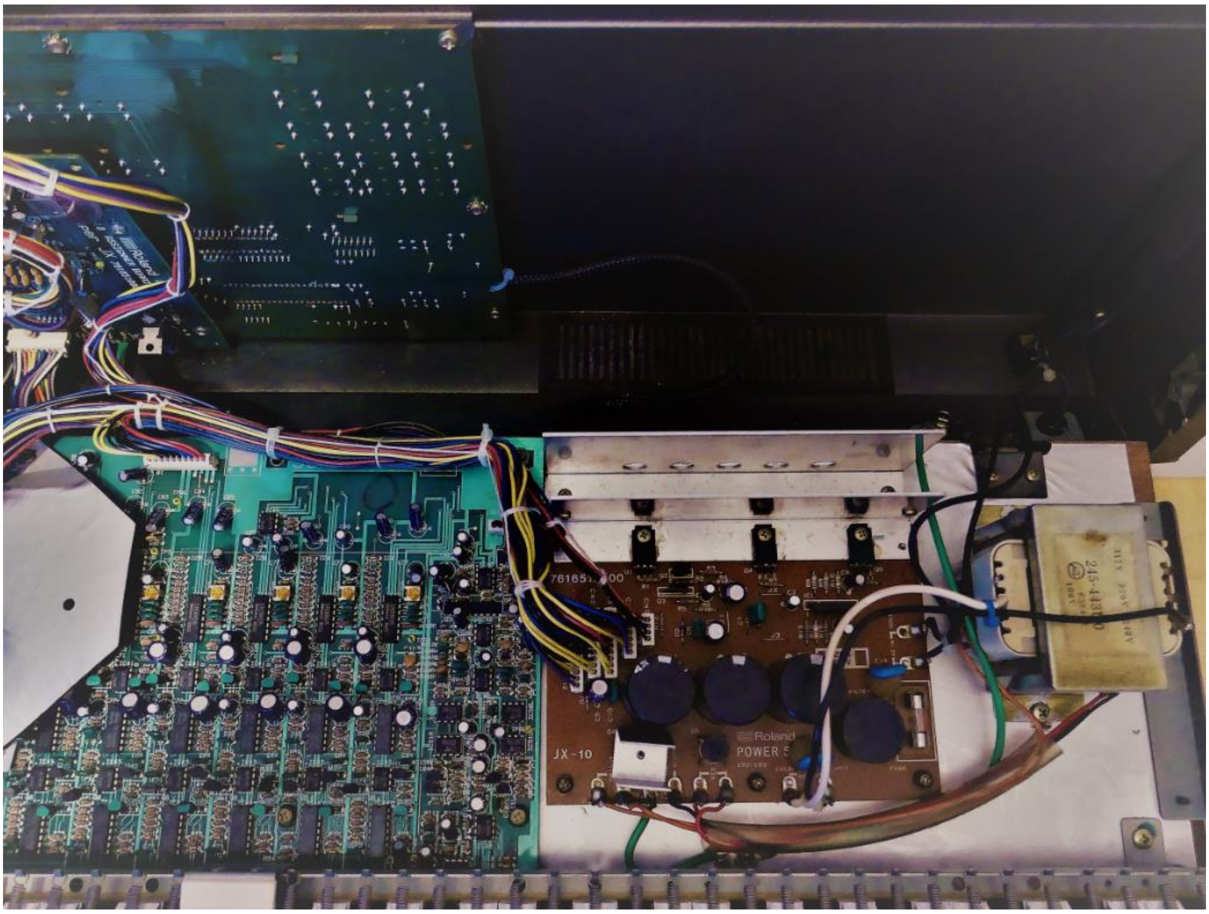
### 7.1.2 JX10 Enclosure & Power Arrangement

The JX10 is fully shielded as it has a plywood base coated with a layer of aluminium foil, the side cheeks are made of moulded plastic and all other enclosure parts are made of metal. The right hand side cheek sits on top of a metal side panel such that without the side cheeks it is impossible to reach inside the instrument.

Earth wires are used to connect all large metal parts and the foil on the base. Metal assemblies (keyboard, top panel hinges) come into contact with the foil as well as a grounding tag. Multiple failures are required for the protective earth to be compromised.

The Roland power Supply Board for the JX10 contains a power filter and fuse to output of which connects directly to the transformer. The input is wired to the mains input via a mains switch on the rear panel. The switch disconnects only the live connection as it arrives from the mains input connector.

A picture of the internals in the area of the power supply is shown below, note that this is a Japanese import that has the mains lead arriving through a grommet. It can be easily switched to an IEC / EN60320-1 style 3 pin mains inlet.



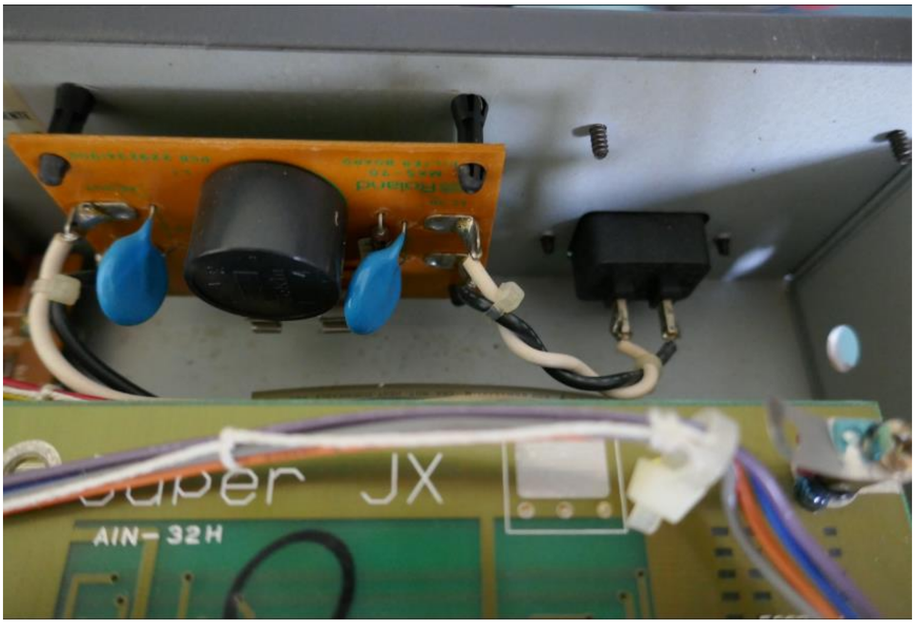
### 7.1.3 MKS70 Enclosure & Power Arrangement

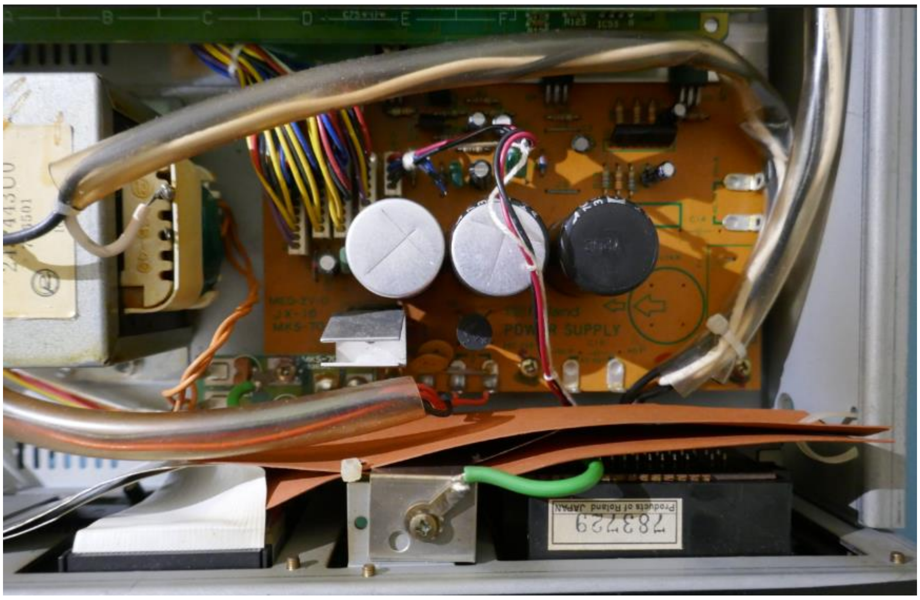
The MKS70 case is made of metal with base assembly welded to together. The top lid is the usual “U” shape that slides over the base assembly. There are ventilation slots that are 2mm x 20mm in the top surface that make it impossible for a human finger to protrude through and come into contact with mains voltages.

The Roland Power Supply Board from the JX10 was used in the MKS70 with the mains filter and fuse components unpopulated, this was because when installed, the mains input terminals situated at the edge of the PCB were too close to the casing. An external filter board was added at the back of the enclosure adjacent to the mains power inlet that is “always live” with the output of it wired to the input of the front panel mounted mains switch. All mains terminals and connections are soldered and exposed.

The pictures below show the depopulated power supply board, mains input 2 pin connector and filter.

Additionally, the ferrite bead based filter between transformer and Power supply Board can be seen to prevent conducted emissions from reaching the mains supply.



## 7.2 Installation Recommendations

For electrical safety, the replacement PCB design follows class II with additional clearances for extra security. However, the ACDC converters collectively only meet class I insulation due to their total input to output capacitance.

The installer may choose to follow the original configuration designed in 1986, however rules have since been amended and therefore it is recommended that the following is performed:

- Fit an IEC / EN60320-1 3 pin mains inlet
- Insulate all exposed mains connections
- Earth the appliance using minimum 6 Amp rated mains wire
- Use a moulded power cord with a 3 Amp or 5 Amp fuse
- Confirm that all metal sub assemblies have an earth wire
- Fuse on new replacement power supply is as specified
- JX10: Consider replacing the power switch

### 7.2.1 Earthing

It is important to note the importance of earthing the appliance when considering that the appliance could be used with headphones.

For non-UK appliances, replacing the 2 pin inlet with a 3 pin ensures that a protective earth is installed. The IEC 3 pin inlet is standard amongst much professional audio gear and is a more convenient solution when sharing and routing cables in racking.

Adding a protective earth in line with the original Roland build standard for 240VAC operation will provide safety protection for all countries.

### 7.2.2 Rewiring

#### 7.2.2.1 Wire

Mains wire capable of carrying 6 amps must be used, for example, 0.75mm$^2$ or 1mm$^2$ (18AWG) 600V Tri-Rated (BS 6231 or H07V2-K). All wire, including earth, has to have the same rating as the IEC mains cable and fuse rating.

#### 7.2.2.2 Crimping

Using “Quick Disconnect” crimp terminals rather than soldering is easier and removes possibility of heat damage, for example Panduit DNF18-187FIB-C - Quick Disconnect Terminal, DNF-FIB Series, Female Quick Disconnect, 4.8mm x 0.8mm, Farnell: 2803161, Mouser: 644-DNF18-187FIB-C.

For earth connections that are bolted, use ring terminals (do not use the open “U” type). Red can only accept a single wire, blue can accept two wires. Like the original Roland design, ensure that the shake proof washer in the original instrument is used under the terminal against the metal work so that it makes good contact by piercing through the paintwork.

#### 7.2.2.3 Soldering

Use heat shrink sleeving to insulate all soldered connections.

When soldering terminals be careful not to overheat, the plastic bodies can become distorted. It is recommended to tin the terminals first before looping the wire through to make soldering rapid.

Earth terminals need to use solder tags, the ones already inside the instrument can be removed, cleaned up and reused. Alternatively, use crimped lugs.

#### 7.2.2.4 JX10

It is recommended to rewire with new 1.00mm$^2$ or 0.75mm$^2$ 1500V rated type that is normally used for 6 Amp mains cable. Ensure that the front panel and keyboard assembly are earthed. It is also good practice to earth the metal bar in front of the keyboard assembly.

#### 7.2.2.5 MKS70

The enclosure is all steel welded construction and wiring is inside sleeving for added safety. Change the mains inlet to 3 pin type and add earth to casing. Insulate all remade mains connections with sleeving or use insulated crimp terminals.

Connect the mains wires that would ordinarily connect to the transformer directly to the replacement power supply board.

The existing Roland power filter (that connects to the front mounted power switch) can remain, provided that the fuse on it is upgraded to a 2 Amp Time Delay type (T2A).

The power filter and traces on the Roland filter board are rated up to continuous 2 Amps. The SE-02-15E choke used in the Roland filter is shown below:

NEC/TOKIN **Common mode**

**SC Coils – Case Type**
**SC-E, F, V Type**
**[RoHS Compliant]**

| Model | Rated current (A) | Inductance (mH) min. | DC resistance (mΩ/line) max. | Temperature rise(K) max. | Recognized by: | Weight approx. (g) |
|---|---|---|---|---|---|---|
| **SC-02-06E** | 2 | 0.6 | 45 | 40 | | 22 |
| **SC-02-10E** | 2 | 1.0 | 55 | 40 | | 22 |
| **SC-02-15E** | 2 | 1.5 | 65 | 40 | | 23 |

Alternatively, the Roland filter may be removed completely and the mains wires from the new 3 pin inlet can be wired directly to the switch using the existing wires.

It is recommended not to rewire the front panel mains switch because the front panel would require careful disassembly and reassembly that is not straightforward. Roland have designed the front panel with pieces of insulation placed strategically to meet safety requirements and is best not disturbed.

### 7.2.3 Mounting New Board

Remove the transformer and power board completely and replace with the new power supply board using M4 hex metal spacers and M4 bolts and nuts using at 6 or more fixing points. This is the recommended method.

It is possible to use original mounting hardware provided that it is secure. However, in the JX10, note that the 3 bottom row mounting holes in the Power Supply Board will have to be drilled to 5mm so that the original plastic clips and spacers can be fitted.

In the original design, the JX10 doesn't have a very secure arrangement because self-tapping wood screws were used as the primary means of fixing. Once the power board has been removed and refitted more than once, they don't fix securely in place enough to support the new PCB.

### 7.2.4 JX10 Power Switch

The JX10 has a power switch of adequate average current rating (6A) but would ideally be upgraded to a type with high capacitive inrush capability and fresh contacts that handle inrush current without additional wear that could cause issues. The build and install guide shows the Arcoelectric type with green indicator.

#### 7.2.4.1 Bulgin / Arcolectric

A recommended switch is the Bulgin, 16A SPST H8500V rocker switches as shown below:

Manufacturer part numbers: H8500XBAAC (Green indicator), H8500XBAAA (Red Indicator), H8500VBBB (Unmarked).

Farnell order code: 390010 (Green Indicator) or 389997 (Red Indicator).
Mouser Part number: 167-H8500VBBB (Unmarked)

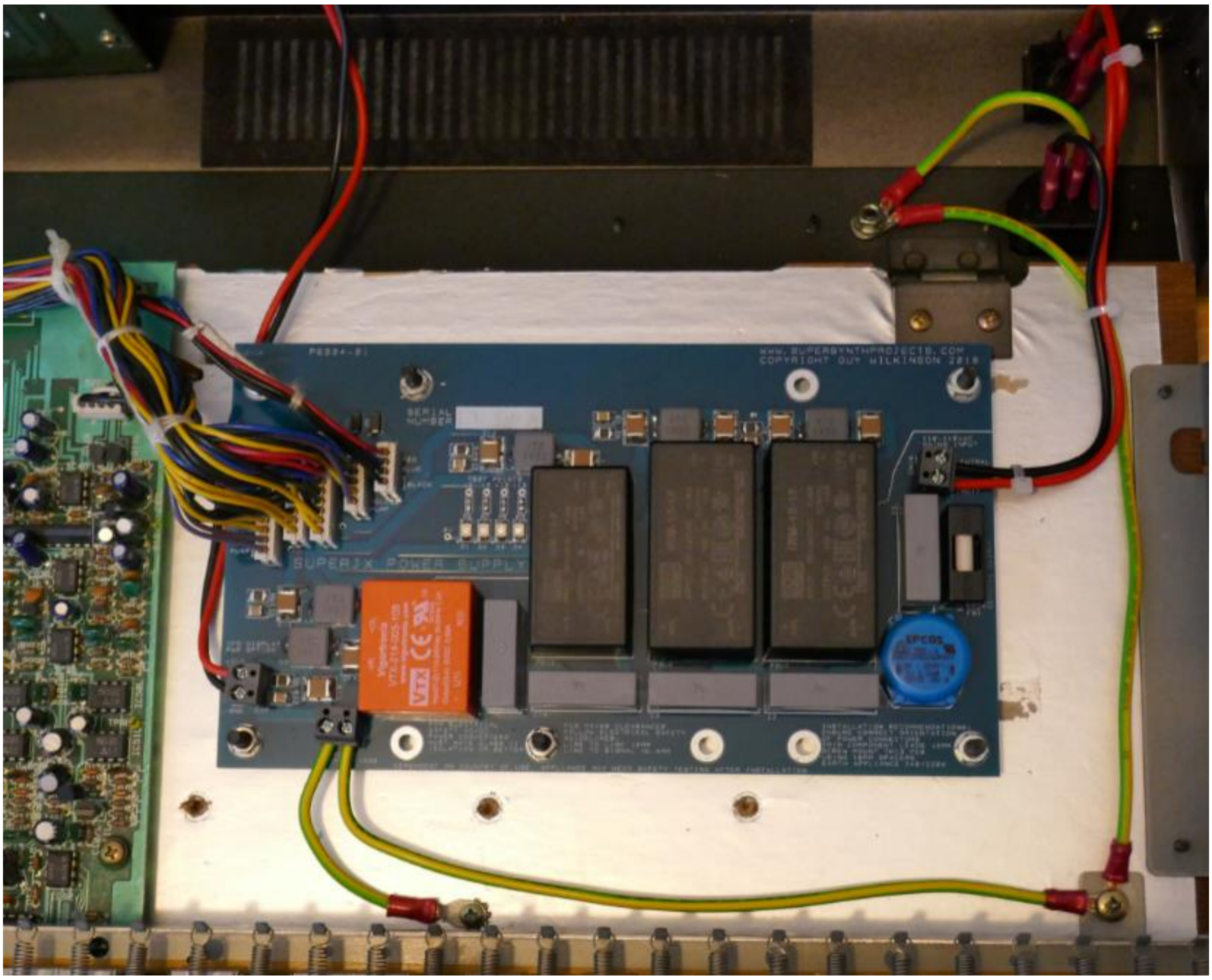
#### 7.2.4.2 Marquardt

A recommended switch is the Marquardt, 12A SPST 1801.1121 / 1908 rocker switch as shown below:

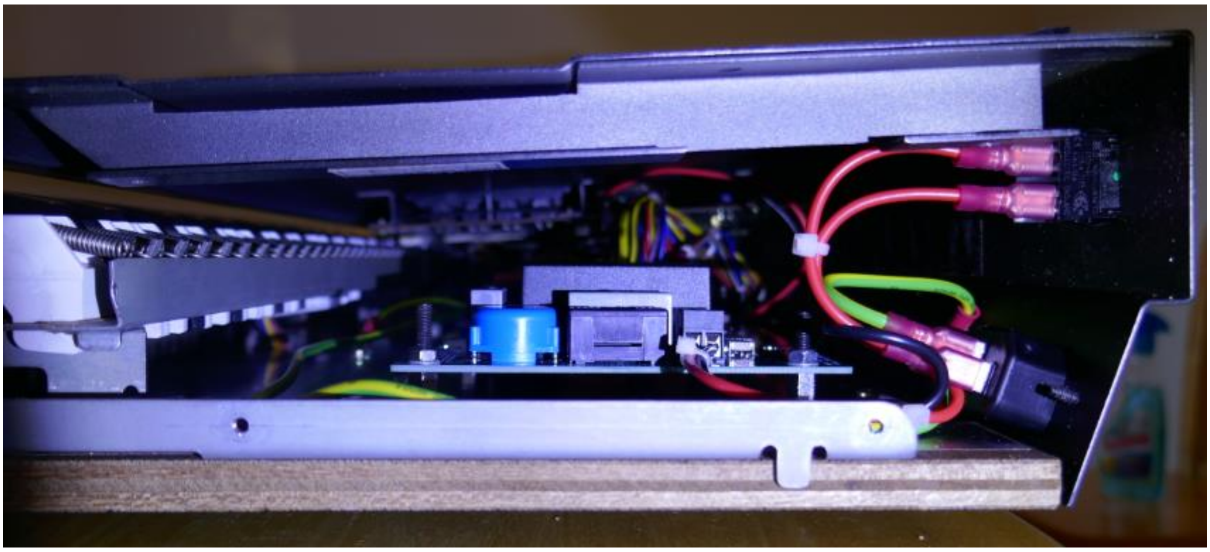

Mouser part number: 979-1801.1908 (Markings), 979-1801.1121 (Blank)

# 8 JX10 Mounting Arrangement

The pictures below show the mounting arrangement inside the JX10 together with new switch and rewiring:



A side view showing the PCB in place after the enclosure is closed but with the end panel removed. There is considerable space around the PCB:



# 9 MKS70 Mounting Arrangement

The MKS70 was not trailed at time of writing, however the electronic circuitry is almost identical to the JX10 and provided that the recommendations are followed with earthing and clearance of mains connections, installers should not have an issue.

The PCB has been designed to use the existing hardware or simply upgrade with new 10mm spacers like the JX10.

Note that mains clearance is such that the PCB traces and components are sufficiently away from the case metalwork therefore unlike the Roland design, mains can be connected onto the PCB. This must be verified by the installer during fitment.

# 10 Performance Testing

The following tests were conducted on the power supply board serial number PS001 between 16th and 24th June 2018 using a Roland JX10 instrument.

## 10.1 Electrical

### 10.1.1 Conclusion

The electrical characteristics meet expectations and requirements for the instrument.

In terms of thermal and efficiency, the ACDC converters did not perform as well as the published data implies, but the derating policy followed ensured that the design was thermally acceptable. Efficiency is improved over the original linear Roland design.

### 10.1.2 No Load

A full set of traces taken from the oscilloscope are available separately. See right hand column for reference number.

| No Load | Equipment | Actual Performance | | Expected Result by Analysis | | | Scope |
|---|---|---|---|---|---|---|---|
| | | Measure | Units | Max | Min | Result | Trace |
| Mains Input | DMM (RMS) | 234 | V AC | N/A | N/A | N/A | |
| Mains Input Current | DMM (RMS) | 54.5 | mA AC | 16.92 | 15.00 | Unexpected | |
| CN1 DC Power +15V Regulation | DMM | 15.02 | V | 15.38 | 14.63 | OK | |
| CN1 DC Power -15V Regulation | DMM | -15.05 | V | -15.38 | -14.63 | OK | |
| CN1 DC Power +5V Regulation | DMM | 4.99 | V | 5.13 | 4.88 | OK | |
| CN1 DC Power +9V Regulation | DMM | 9.14 | V | 9.18 | 8.82 | OK | |
| Display Power Regulation | DMM | 9.14 | V | 9.18 | 8.82 | OK | |
| PSU1 Out AC PkPk Ripple | Scope | 42.1 | mV | 200.00 | 20.00 | OK | 0, 1 |
| CN1 DC Power +15V AC PkPk Ripple | Scope | 11.2 | mV | 50.00 | 0.00 | OK | 2 |
| PSU2 Out AC PkPk Ripple | Scope | 42 | mV | 200.00 | 20.00 | OK | |
| CN1 DC Power -15V AC PkPk Ripple | Scope | 11.4 | mV | 50.00 | 0.00 | OK | |
| PSU3 Out AC PkPk Ripple | Scope | 38.4 | mV | 200.00 | 20.00 | OK | |
| CN1 DC Power +5V AC PkPk Ripple | Scope | 38.4 | mV | 50.00 | 0.00 | OK | |
| PSU4 Out AC PkPk Ripple | Scope | 42.5 | mV | 200.00 | 20.00 | OK | 5, 6 |
| CN1 DC Power +9V AC PkPk Ripple | Scope | 11.2 | mV | 50.00 | 0.00 | OK | |
| Display Power +9V AC PkPk Ripple | Scope | 11.2 | mV | 50.00 | 0.00 | OK | |

Current consumption is higher than expected probably because the ACDC converters are not in quiescent mode and regulating power to supply the LEDs.

### 10.1.3 Maximum Rated Load

A full set of traces taken from the oscilloscope are available separately. See right hand column for reference number.

| Resistive Loaded 15V@1A/5V@1.7A/9V@0.54A | Equipment | Actual Performance | | Expected Result by Analysis | | | Scope |
|---|---|---|---|---|---|---|---|
| | | Measure | Units | Max | Min | Result | Trace |
| Mains Input | DMM (RMS) | 234 | V AC | N/A | N/A | N/A | |
| Mains Input Current | DMM (RMS) | 332.9 | mA AC | 277.87 | 230.08 | Unexpected | |
| PSU1 Out DC Power +15V regulation | DMM | 14.96 | V | 15.38 | 14.63 | OK | |
| CN1 DC Power +15V Regulation | DMM | 14.79 | V | 15.26 | 14.48 | OK | |
| L2 Voltage Drop | DMM | 141.6 | mV | 118.42 | 71.05 | Unexpected | |
| PSU2 Out DC Power -15V regulation | DMM | -15 | V | -15.38 | -14.63 | OK | |
| CN1 DC Power -15V Regulation | DMM | -14.81 | V | -15.49 | -14.77 | OK | |
| L3 Voltage Drop | DMM | -148.8 | mV | -118.42 | -71.05 | Unexpected | |
| PSU3 Out DC Power +5V regulation | DMM | 4.98 | V | 5.13 | 4.88 | OK | |
| CN1 DC Power +5V Regulation | DMM | 4.87 | V | 5.08 | 4.83 | OK | |
| L4 Voltage Drop | DMM | 65.9 | mV | 46.92 | 28.15 | Unexpected | |
| PSU4 Out DC Power +9V regulation | DMM | 9.14 | V | 9.18 | 8.82 | OK | |
| CN1 DC Power +9V Regulation | DMM | 9.11 | V | 9.16 | 8.80 | OK | |
| L5 Voltage Drop (Loaded to 540mA) | DMM | 22.2 | mV | 24.59 | 14.75 | OK | |
| Display Power Regulation | DMM | 9.11 | V | 9.16 | 8.80 | OK | |
| L6 Voltage Drop (Loaded to 540mA) | DMM | 22.2 | mV | 23.92 | 14.35 | OK | |
| PSU1 Out AC PkPk Ripple | Scope | 68 | mV | 200.00 | 20.00 | OK | 7 |
| CN1 DC Power +15V AC PkPk Ripple | Scope | 8.8 | mV | 50.00 | 0.00 | OK | 8 |
| PSU2 Out AC PkPk Ripple | Scope | 58.4 | mV | 200.00 | 20.00 | OK | |
| CN1 DC Power -15V AC PkPk Ripple | Scope | 6 | mV | 50.00 | 0.00 | OK | |
| PSU3 Out AC PkPk Ripple | Scope | 184 | mV | 200.00 | 20.00 | OK | 10 |
| CN1 DC Power +5V AC PkPk Ripple | Scope | 4.16 | mV | 50.00 | 0.00 | OK | 9 |
| PSU4 Out AC PkPk Ripple | Scope | 142 | mV | 200.00 | 20.00 | OK | 11 |
| CN1 DC Power +9V AC PkPk Ripple | Scope | 31.6 | mV | 50.00 | 0.00 | OK | 12, 13 |
| Display Power +9V AC PkPk Ripple | Scope | 31.6 | mV | 50.00 | 0.00 | OK | |

Current consumption is slightly higher than expected more likely because efficiency is probably closer to 75% (rather than predicted 80%).

Voltage drop across the filters was higher when measured but likely cause is increased inductor resistance due to heating.

### 10.1.4 Powering Instrument

A full set of traces taken from the oscilloscope are available separately. See right hand column for reference number.

| Powering Instrument (VFD/PWM) | Equipment | Actual Performance | | Expected Result by Analysis | | | Scope |
|---|---|---|---|---|---|---|---|
| | | Measure | Units | Max | Min | Result | Trace |
| Mains Input | DMM (RMS) | 238 | V AC | N/A | N/A | N/A | |
| Mains Input Current | DMM (RMS) | 156 | mA AC | 148.11 | 105.76 | Unexpected | |
| CN1 DC Power +15V Regulation | DMM | 14.95 | V | 15.33 | 14.58 | OK | |
| L2 Voltage Drop | DMM | 41.5 | mV | 45.00 | 27.00 | OK | |
| CN1 DC Power -15V Regulation | DMM | -14.98 | V | -15.25 | -14.65 | OK | |
| L3 Voltage Drop | DMM | 45.3 | mV | 45.00 | 27.00 | Unexpected | |
| CN1 DC Power +5V Regulation | DMM | 4.94 | V | 5.09 | 4.85 | OK | |
| L4 Voltage Drop | DMM | 27.2 | mV | 35.00 | 21.00 | OK | |
| CN1 DC Power +9V Regulation | DMM | 9.08 | V | 9.18 | 8.82 | OK | |
| L5 Voltage Drop (PG800 Connected) | DMM | 1.9 | mV | 3.75 | 0.00 | OK | |
| Display Power Regulation | DMM | 9.06 | V | 9.16 | 8.80 | OK | |
| L6 Voltage Drop | DMM | 12.6 | mV | 17.50 | 10.50 | OK | |
| CN1 DC Power +15V AC PkPk Ripple | Scope | 25.2 | mV | 50.00 | 0.00 | OK | 14 |
| PSU1 Out AC PkPk Ripple | Scope | 40.8 | mV | 200.00 | 20.00 | OK | 15, 16 |
| CN1 DC Power -15V AC PkPk Ripple | Scope | 18 | mV | 50.00 | 0.00 | OK | |
| PSU2 Out AC PkPk Ripple | Scope | 33.6 | mV | 200.00 | 20.00 | OK | |
| CN1 DC Power +5V AC PkPk Ripple | Scope | 34 | mV | 50.00 | 0.00 | OK | 17 |
| PSU3 Out AC PkPk Ripple | Scope | 88 | mV | 200.00 | 20.00 | OK | 18, 19 |
| CN1 DC Power +9V AC PkPk Ripple | Scope | 43.2 | mV | 50.00 | 0.00 | OK | |
| PSU4 Out AC PkPk Ripple | Scope | 154 | mV | 200.00 | 20.00 | OK | 20, 21 |
| Display Power +9V AC PkPk Ripple | Scope | 55.2 | mV | 200.00 | 0.00 | OK | 22, 23 |
| Note that ripple is primarily result of instrument conducted emissions & loading. | | | | | | | |

Current consumption is slightly higher than expected more likely because efficiency is probably closer to 75% (rather than predicted 80%) with the current demands from the instrument.

## 10.2 Thermal

### 10.2.1 Conclusion

The new power supply runs dramatically cooler than the old design leading to a lower temperature rise and smaller “hot area” on the top of the casing.

New design is adequately rated for an upgraded instrument from a thermal management perspective.

Testing at maximum load, thermal performance of the Mean Well converters was not as good as published data but the design was sufficiently derated to keep temperature rise to no more than 30 degrees for powering an instrument.

### 10.2.2 Maximum Rated Load

Free air 240VAC mounted on 10mm spacers.

| Resistive Loaded 15V@1A/5V@1.7A/9V@5.4A | | | | | |
|---|---|---|---|---|---|
| **ACDC Temperature measurement** | **Position** | **Ambient** | **Temp deg C** | **Rise** | **Projected @ 35 degC** |
| ***After 1 Hour*** | | | | | |
| PSU1 | center | 22.5 | 57.5 | 35.0 | 70.0 |
| PSU1 | DC terminals | 22.5 | 54.5 | 32.0 | 67.0 |
| PSU2 | center | 22.5 | 53.5 | 31.0 | 66.0 |
| PSU3 | DC terminals | 22.5 | 46 | 23.5 | 58.5 |
| PSU4 | center | 22.5 | 37.5 | 15.0 | 50.0 |

### 10.2.3 Powering Instrument Open Case

Free air, enclosure open, 240VAC with correct mounting method (10mm spacers). Instrument is fully upgraded with PWM and VFD

| Powering Instrument (VFD/PWM) - Open Casing | | | | | |
|---|---|---|---|---|---|
| **ACDC Temperature measurement** | **Position** | **Ambient** | **Temp deg C** | **Rise deg C** | **Projected @ 35 degC** |
| ***After 1 Hour*** | | | | | |
| PSU1 | center | 22 | 44.5 | 22.5 | 57.5 |
| PSU2 | center | 22.5 | 44.5 | 22.0 | 57.0 |
| PSU3 | center | 22.5 | 45.5 | 23.0 | 58.0 |
| PSU4 | center | 22.5 | 42 | 19.5 | 54.5 |
| ***After 2 Hours*** | | | | | |
| PSU1 | center | 20.5 | 45.5 | 25.0 | 60.0 |
| PSU2 | center | 20.5 | 48.5 | 28.0 | 63.0 |
| PSU3 | center | 20.5 | 47 | 26.5 | 61.5 |
| PSU4 | center | 20 | 43 | 23.0 | 58.0 |

### 10.2.4 Powering Instrument Closed Case

Enclosure closed, 240VAC with correct mounting method (10mm spacers). Instrument is fully upgraded with PWM and VFD

| Powering Instrument (VFD/PWM) - Closed Casing | | | | | |
|---|---|---|---|---|---|
| **Temperature measurement** | **Position** | **Time Hr** | **Ambient** | **Temp deg C** | **Rise deg C** |
| Inside case between CN2 and CN3 | DC Power Wires | 1 | 22.5 | 29 | 6.5 |
| Outside case, hottest part 10mm NW "TONE EDIT MAP" label. Hot area approx 20x60mm | Lid | 2 | 22.5 | 29 | 6.5 |

### 10.2.5 Powering Standard Instrument Closed Case

Enclosure closed, 240VAC. Instrument is fully upgraded with PWM and VFD but uses the original linear power supply.

| Powering Instrument with Roland PSU (VFD/PWM) - Closed Casing | | | | | |
|---|---|---|---|---|---|
| **Temperature measurement** | **Position** | **Time Hr** | **Ambient** | **Temp deg C** | **Rise deg C** |
| Outside case, hottest part 10mm NW "TONE EDIT MAP" label, hot area 150x100mm | Lid | 2 | 22.5 | 34 | 11.5 |

## 10.3 Earth Leakage

### 10.3.1 Conclusion

The instrument has to have a protective earth fitted when using this replacement power supply.

Individually the ACDC converters can meet class II isolation, collectively they cannot due to their input-output capacitance of 500pF leading to a leakage current of 0.283mA at 240VAC.

### 10.3.2 Measurements

Two methods were used to confirm the value, a current measurement and voltage measurement using a 10Kohm shunt.

| Test Performed | |
|---|---|
| **Leakage Test Method** | **Leakage @ 240VAC mA** |
| AC RMS Milliameter (Low resolution) | 0.2 |
| Resistive shunt 10K ohm AC RMS DVM (Accurate) | 0.283 |

| Conclusion |
|---|
| Replacement power supply does not meet class II isolation, therefore the instrument should be wired as class I, i.e. with a protective earth.<br><br>Using measurement, it can be calculated that on average, each ACDC converter has an input to output capacitance of 500pF that leads to this leakage. It is likely that the close coupling of the output transformers and internal layout and expected.<br><br>Projected leakage for USA 110VAC is 0.130mA. |

## 10.4 Fuse

### 10.4.1 Conclusion

ACDC converters have high input capacitance of approximately 10uF in order to smooth rectified mains. It results in a high inrush current that has to be accounted for in the choice of fuse.

The fuse chosen, 2 Amp time delay is a compromise between nuisance tripping and maximum rating of the PCB components.

### 10.4.2 Cycle Tests

| | |
|---|---|
| Fuse Type | Time Delay |
| Approval standard | IEC60127-2 |
| Manufacturer | Littelfuse |
| Part Number - T1A | 0215001.MXP |
| Opened after 23 cycles of unloaded and pulling plug (worst case) from wall socket. Deemed borderline and expected. | |
| Part Number - T2A | 0215002.MXP |
| Didn't open after 30 cycles of pulling plug from wall socket.<br>Didn't open after 30 cycles of power switch on Roland JX10 performed 3 per day over 2 weeks. | |

| | |
|---|---|
| Fuse Type | Fast Blow |
| Approval standard | DIN41660 |
| Manufacturer | Wickmann |
| Part Number - 2A | F2A19194 |
| Didn't open after 30 cycles at maximum power rating. Unexpected result because fast blow do not tolerate inrush current. | |

| **Summary** | |
|---|---|
| Part Chosen: 2Amp IEC Time Delay | 0215002.MXP |
| Aligns with results from model, T2A fuse type required. | |

Although not the correct type for this application, a 2 Amp fast blow type (F2A) was tested for interest, it functioned satisfactorily for 30 power on cycles before being changed for a T2A type.