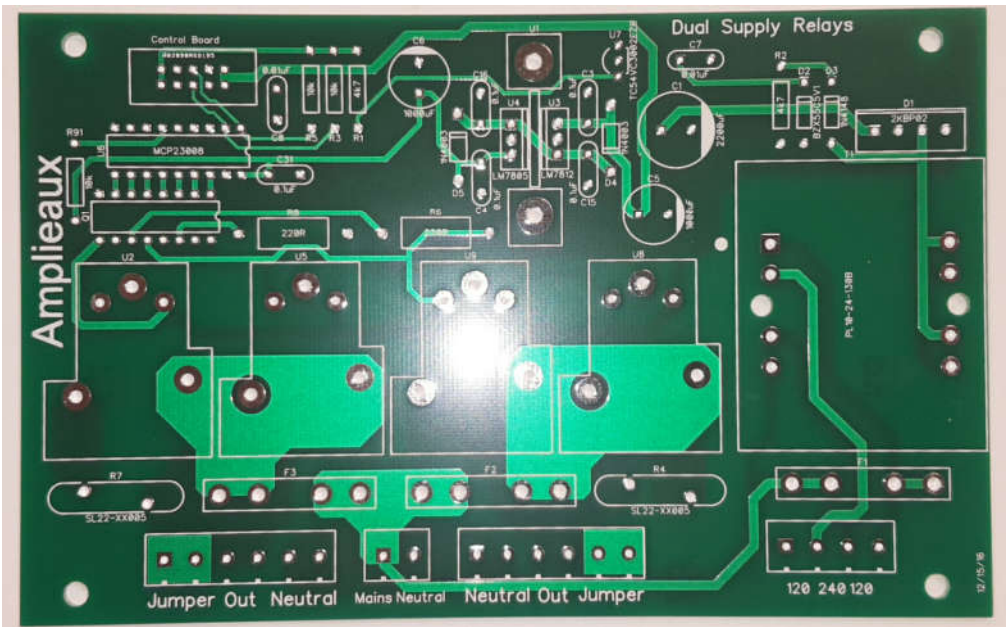


Through Hole Dual Digital Supply



The Through Hole Control Supply/Relay board takes care of fusing and soft-starting of a single main supply transformer. It has an on-board control transformer and supplies for the control board and has a voltage loss detector circuit too. It communicates with the control board and receives commands from it for relay operation.

Operation

Mains power from the rear panel of the amplifier connects to the supply/relay board. The on-board control transformer steps mains voltage down to 12VAC. This voltage is rectified, then regulated to two outputs, one at 12VDC, and the other at 5VDC. The 12VDC supply powers the on-board relays for the main supply transformer and the optional auxiliary supply transformer. The 5Vdc supply powers the control circuitry for the relays and is fed to the control board through a stacking header. The voltage loss detector signals the control board of brown out or intermittent mains power loss. There is also a mains voltage selector allowing for 120VAC or 240VAC operation. Communication between the control board and the power relays is done though an I2C bus and port expander.

Bom

Qty	RefDes	Name	Value	Mouser	Digikey	Newark
1	C1	12.5x25x5	2200uF	647-UVY1H222MHD	493-12472-ND	55K2342
5	C3, C4, C15, C16, C31	CAP200	0.1uF	80-C322C104K1R	399-9875-1-ND	18K5742

2	C5, C6	10x12x5	1000uF	647-UPW1V102MHD	493-1872-ND	55K0325
2	C7, C8	CAP200	0.01uF	80-C315C103K1R	399-9857-1-ND	30X0625
1	D1	2KBP02		625-2KBP02M-E4/51	2KP02M-E4/51GI-ND	78K3301
1	D2	Zener	BZX55C5V1	78-BZX55C5V1	BZX55C5V1GICT-ND	55R1524
1	D3	1N4148	1N4148	512-1N4148	1N4148FSTR-ND	05R0353
2	D4, D5	1N4003 FUSE	1N4003	863-1N4003G	1N4003GOS-ND	87X9764
3	F1, F2, F3	22.86	64600001003	576-64600001003	WK6244-ND	67K2308
3	Fuse Cover			576-64000001003		67K2307
1	J1	282836-4		571-2828364	A98078-ND	12H8397
1	J2	Rear Panel	52601-S10-4LF	649-52601-S10-4LF	609-3592-ND	84K5868
2	J4, J5	282836-6		571-2828366		
1	J6	282836-2		571-2828362		
1	Q1	ULN2003A		595-ULN2003AN	296-1979-5-ND	60K7049
2	R1, R2	RES500	4k7			58K3858
3	R3, R5, R91	RES500	10k			58K3797
2	R4, R7	120VAC	SL22-20005	995-SL22-20005	570-1139-ND	
1	R7	240VAC	SL22-40005	995-SL22-40005	570-1049-ND	
2	R6, R8	RES700	220R	660-MOS1CT52R221J		
1	T1	PL10-24-130B	PL10-24-130B	838-PL10-24-130B		
1	U1	Heatsink	531302B02500G	532-531202B25G	HS382-ND	18M8179
4	U2, U5, U8, U9	T90 SPST NO		655-T90S1D12-12	PB110-ND	17M3075
1	U3	LM7812CT	LM7812	512-LM7812ACT	LM7812ACT-ND	31Y2365
1	U4	LM7805CT	LM7805	512-LM7805ACT	LM7805ACT-ND	17M3075
1	U6	MCP23008	MCP23008	579-MCP23008-E/P	MCP23008-E/P-ND	08J8737
1	U7	TC54_ZB	TC54VC3002EZB	579-TC54VC3002EZB	TC54VC3002EZB-ND	

Note- Select appropriate value for R4 and R7 to match your mains supply voltage

Tools Required

These instructions are written assuming you are using a conventional soldering iron. Basic tools and supplies are required. You will need a fine tip for small parts, as well as a large tip for the microcontroller and large Mosfets. It's good to have two irons available in case small part removal is needed. A good temperature controlled 40W station set to 700F makes soldering very easy. A good alternate method is a hot air rework station. Aside from this you will need the following:

- Isopropyl alcohol
- Liquid or gel flux
- Flux remover
- Good quality flux core solder

- Solder wick or a solder sucker
- Good quality fine tip tweezers
- A good light. A Luxo type with a fluorescent ring tube bulb and magnifier works great
- Multimeter
- A clean work surface, preferably over a smooth hard freshly swept floor. This make finding a small part that escaped the tweezers much easier.

Assembly

To begin, first wash the circuit board thoroughly with isopropyl alcohol. Wipe it dry with clean paper towel and immediately coat all solder pads with liquid or gel flux to prevent oxidization.

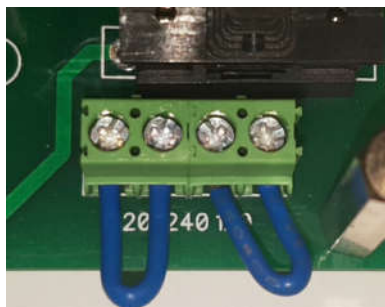
Proceed with assembly by installing all the lower height parts first, and work your way up to the tallest parts.

Follow soldering by washing all the excess flux off the board. Flux remover or Isopropyl alcohol will remove most of the goo. This can be followed by a mild soap and water wash and distilled water rinse if you used the suggested wash approved relays. Allow some time for complete air drying before applying power.

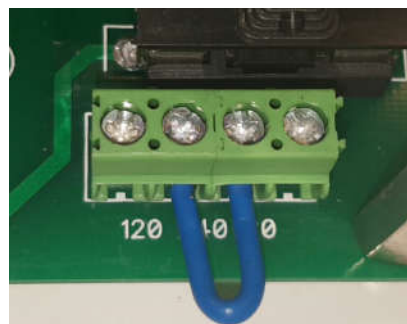
Testing

First visually inspect everything and measure for continuity and shorts with a meter. If everything looks good, it's time to apply power.

Next line voltage needs to be selected for the control transformer with J1. For 120VAC operation install a jumper wire from 1-2 and another from 3-4. For 240V operation, install a jumper wire from 2-3 only.



120VAC Operation



240VAC Operation

Install a fuse for the control transformer in F1. Install an appropriately rated fuse to match your transformers in F2 and F3. To select an appropriately sized fuse, find your current rating of the input of the transformer and multiply this by 1.25 for a maximum acceptable current rating.

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Next measure voltage across D2. It should be between 3 – 5.1V. This is the voltage detector circuit and measurements will vary a lot between builds and aren't critical.

Once the control board is operational, verify relay operation on power up. U2 should be active first followed quickly by Q8. There should be a delay for whatever the inrush delay is set to in the software, then U5 and U9 should activate, followed by a delay for speaker relay engagement, then U2 and U8 should open. At this point, U5 and U9 should be powered through power saving resistors. This can be verified by measuring voltage across R6 and R8. If there is voltage present, the resistors are in operation.

Voltage detector operation can be tested as well. When the supply is connected to mains power 5V should be present on pin 1 of U7. This can be measured more easily at R1. It's tough to activate the circuit manually. You would need to quickly disconnect and reconnect mains power from the supply to activate it, but you would need to do this faster than the 5V supply caps could drain and reset the microcontroller. The simplest way to test this is to short pin 2 and pin 3 of U7 momentarily. This part of the circuit is current limited and can be shorted indefinitely with no risk of damage. The power loss detection circuit should operate and the control board should shut down the amplifier signaling power loss through the front panel LED.

Circuit Explanations

Control Supplies

Mains power is fed to the control portion of the circuit board through F1 to protect the control transformer from overcurrent. Mains power is then fed to the control transformer and through a series/parallel selector terminal block(J1). The input side of the transformer has two 120VAC windings. The series/parallel terminal block allows use to run these windings in parallel for 120VAC operation, or in series for 240VAC operation. The control transformer steps the mains voltage down from dual 120VAC inputs to dual 12VAC outputs. The outputs are connected in parallel to a bridge rectifier(D1), which changes the 12VAC input to around 17VDC output. Raw DC exiting the bridge rectifier is very rough, so we pass it to C1 to remove some of the ripple from the voltage.

Our circuits require two lower voltages to operate. We need 5VDC for our digital circuits, and 12VDC for our relays. We pass the raw DC to U3, past C15 to decouple U3 from the rest of the circuit (U3 will store a small amount of current that can be used by U3 as needed without affecting the voltage stored at C1, so it won't affect the operation of any other circuits connected to C1). U3 regulates the raw voltage to 12VDC (to do this, U3 passes its output voltage through a resistor to ground and measures the current flowing through this resistor. It adjusts the amount of current it passes to the output to maintain this constant current reading through the resistor to ground).

Output from U3 is passed to a reservoir capacitor (C5). D4 is added to protect U3 when mains power is removed. When this happens, there is the possibility that the voltage at C1 may become lower than the voltage at C5, which would cause current to flow backwards through U3, causing damage. Instead, current will flow through D4 and minimize the voltage difference.

We regulate our 5V supply the same way through U4 and its associated parts.

Voltage Loss Detection

We take a small amount of AC current from the output of the control transformer and rectify it through D3. We use AC output as opposed to DC from after D1 because there will be some current stored in C1 that would provide voltage to the detector circuit for a short time after mains power is lost, slowing down the voltage detector circuit.

U7 is a specialized voltage detector IC. It looks for a minimum voltage at its input pin (pin 2). If it doesn't see its minimum voltage, it connects its output pin (pin 1) to ground (pin 3). If it sees its minimum voltage, it opens the connection between its output and ground.

U7's input can't withstand high voltage, so we limit its voltage with a Zener diode (D2) and limit the current to it through R2 so D2 won't burn up. The voltage delivered through D3 is pretty rough, so we add C7. We keep the value of C7 small so it won't store much of a charge, keeping the reaction time of U7 fast.

Digital circuits require a high or a low state for their inputs. If an input is left floating and is allowed to drift to a voltage level somewhere close to the middle of high or low (+5 or 0 in this case) The device reading the signal won't know how to interpret the signal, so it's impossible to tell what it will do in this

situation. With all digital circuits, we can't allow this to happen. To stop this, we use pull up or pull down resistors. A pull up resistor is a resistor usually between 1K and 10 k that will hold the signal line at a high state (5V in this case) until the output from a device or circuit pulls it low. A pull-down resistor does the same thing, but pulls the line to 0V instead, allowing a circuit to pull the line high.

Our microcontroller is looking for a high state input to signal mains voltage is present, so we add R1 to hold the line at 5V until U7 signals a loss of AC mains voltage and pulls the line low. We add D7 to smooth out any noise on the line from other circuits sharing the 5V supply.

Relay Driver circuits

We use a port expander and a Darlington relay driver to control out power relays. The port expander allows us to control up to eight outputs from a pair of digital signal lines. In this case we use a MCP23008 expander from Microchip. The MCP23008 has 8 I/O pins, meaning it has 8 pins that can be read as digital inputs, or used as digital outputs, depending on how we tell it to operate in the software on the master controller.

In the setup code in our Amp Control software we tell the port expander to use the I/O pins as outputs.

```
Wire.beginTransmission    (relayAddress); // this tells the expander we want to talk to it
Wire.write                (0x00); //selects the register we want to write to
Wire.write                (0x00); //this sets all pins to outputs
Wire.endTransmission      (); //stops talking to device
```

When we want an I/O pin to switch to a high state (on) we “write” that pin high in the software. To do this we need to send an 8-bit message to the expander in MSB (Most Significant Bit first) format. What this means is we send a message consisting of eight binary (either 1 or 0) digits to the expander. MSB means the first digit will be the state of I/O pin 7 and the last digit will be I/O pin 0. For example, if we want to turn on I/O pin 5 & 6 while having the rest turn off we would send a message saying B0110000. The B on the front of the message tells the software that it's a binary value.

```
Wire.beginTransmission    (relayAddress); // this tells the expander we want to talk to it
Wire.write                (0x09); //selects the GPIO pins
Wire.write                (B01100000); // this turns on I/O pins 5 and 6
Wire.endTransmission      (); //stops talking to device
```

The actual message can be converted to other methods of communication. Hexadecimal format is popular and I use it as well. B01100000 converts to 60 in hexadecimal. We add a 0x in front to tell the software we are speaking in hexadecimal.

```
Wire.beginTransmission    (relayAddress); // this tells the expander we want to talk to it
Wire.write                (0x09); //selects the GPIO pins
Wire.write                (0x60); // this turns on I/O pins 5 and 6
Wire.endTransmission      (); //stops talking to device
```

The MCP23008(U6) data lines require a good crisp 5V or 0V for clear communication. Our master controller can pull these lines low, but needs help to hold them high, so we add R3 and R5 pull up resistors to give a good 5V. U6 also needs to see a high state at it's reset pin so we add R91.

We take the output from U6 and control Q1 with it. Q1 takes a high state (5V) low current input which switches it's output pin to a high current low state (ground). We use this output to switch relays off or on as needed. Output 1 of Q1 is connected to U2. The opposite side of the coil of U2 is connected to 12V. When input 1 of Q1 is fed a high state, it grounds the coil of U2, causing it to activate. When the high state is removed from input 1 of Q6, the output is returned to a high state and the relay is deactivated.

When a relay coil is de-energized, a magnetic field collapses across the coil, producing a large AC voltage spike. Q1 has on board diodes that will direct this AC spike back into the 12V supply and damp it out quickly.

A relay takes much more current to pull in a set of contacts than it does to hold them in, so to save current we put R6 and R8 in series with the power relays to lower current flow after the relay is engaged.

