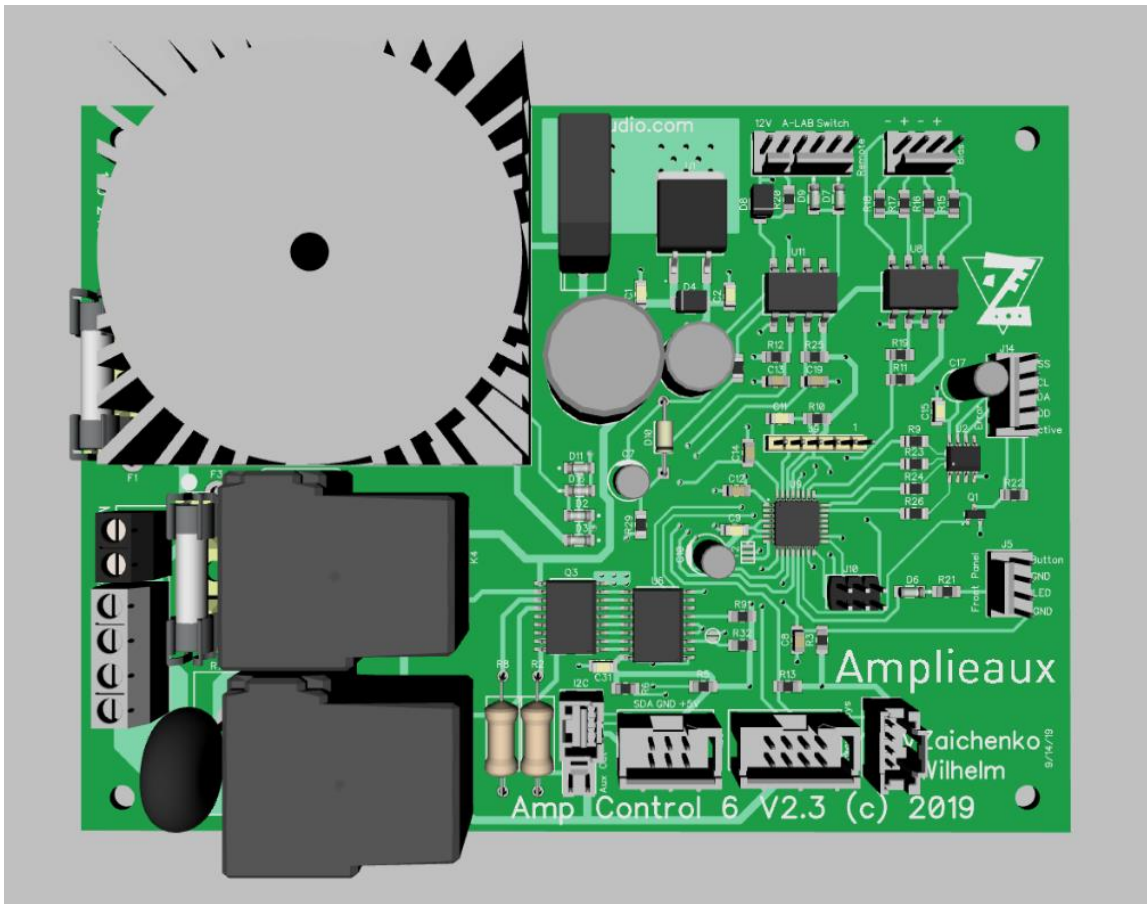


Amp Control 6V2.3

Control Board Building instructions

AMPLIEAUX

Version 6.03.2, May 23, 2020



Amp Control 6V2.3 is a microprocessor controlled monitoring board that will shut down and send a signal to disconnect speakers on any sign of problem from the amplifiers it is connected to.

Design features are as follows,

- on board current sensing connections that monitor the voltage drop through a pair of emitter resistors of up to two amplifier channels.
- monitors temperature of up to 8 locations with remote temperature sensors connected over an I2C communication bus.
- daisy chain connection to multiple DC detection board/speaker relays.
- on board power relays and fusing that will start and protect one main power transformer for an amplifier and an aux control output to switch a small Aux supply or other option..
- provisions to communicate with power supplies with rail quick shut down Mosfets that can be turned off in the event of an amplifier failure to minimize damage.
- on board mains voltage loss detection circuit to protect the supply transformer from brown outs and intermittent power loss.

- an input for a front panel momentary or latching button, as well as a 12VDC trigger input and a shorted contact trigger input to signal power up.
- front panel LED control that will signal power state and will flash trouble codes if a shutdown event happens.
- expandable through communication over I2C, SPI or serial communication for just about any other imaginable interface need.
- includes connection to external event data logging via level shifted I2C interface.

Operation

Mains from a rear panel connector are fed directly to the Amp Control board. If the Amp Control board receives an on signal from either the front panel switch or a remote trigger signal, it begins a preheat mode if connected to a tube hybrid input amplifier. It then begins a soft-start sequence. It first engages an on board inrush relay that powers one main supply transformer through an on board NTC resistor. If supplies with rail quick shut downs are connected, they are sent an on signal over I2C. Next it engages the main power relays. After a programmed delay, DC detection monitoring begins, after which the speaker relays are engaged and inrush relays are disengaged. Power relay current limiting also begins. Current, temperature and mains voltage loss monitoring immediately begin. If the front panel switch or remote trigger signal is switched off, speaker relays are immediately signaled off, followed by supply rail shut downs if present, the power relays, and then the heater relay.

If a shutdown event occurs, speaker relays are immediately switched off, followed again by supply rail shut downs if present, and the power relays and heater relay are switched off. The front panel LED will begin flashing a trouble code indicating the reason for the shutdown.

- Intensive blinking (every 0.2 sec) - DC offset;
- 1 blink every 2 seconds - AC failure;
- 2 blinks every 2 seconds - overheat;
- 3 blinks every 2 seconds - OPS over-current;

All state change and shut down events are annunciated through an I2C interface as well.

Tools required

There are a few different ways to solder parts to the boards. Reflow ovens or hot air rework stations make very easy fast work of SMD installation, but these instructions will focus on a standard soldering iron.

- Good temperature controlled solder station with a large screwdriver tip, and a fine point tip
- A second iron to aid removal of parts if required (quality not as important for the second iron)
- Good quality fine tip tweezers (cheap tweezers tend to launch more parts across the room)
- Magnifying glass or loupe
- Liquid or gel flux
- .015" flux core solder
- A DMM
- The usual assorted hand tools such as screw drivers and pliers
- A USB to serial adapter

- A USBTinyISP

BOM

| Qty | RefDes | Pattern | Value | Part number | Manufacturer |
|-----|------------------------------|------------------------|-----------------|----------------|-------------------|
| 6 | C1, C2, C9, C11, C15, C31 | CAP_1206 | 0.1uF | C1206C104K1R | KEMET |
| 1 | C4 | 16x25x7.5 | 2200uF | UVZ1V222MHD | Nichicon |
| 1 | C6 | 10x12.5x5 | 1000uF | UVZ1V102MHD | Nichicon |
| 1 | C7 | 6.3x11x2 | 47uF | UPW1E470MDD | Nichicon |
| 5 | C8, C12, C13, C14, C19 | CAP_1206 | 0.01uF | C1206C103K1R | KEMET |
| 1 | C10 | 6.3x11x2 | 10uF | UVZ1E100MDD1TD | Nichicon |
| 1 | C17 | 5x11x2 | 10uF | UVZ1H100MDD | Nichicon |
| 1 | D1 | SIP-4/17.5x6.8x3.8 | | KBL04-E4 | Vishay |
| 7 | D2, D3, D6, D7, D9, D11, D16 | SOD-80 | | PMLL4148L-T/R | Nexperia |
| 2 | D4, D8 | 403D-02 | MRA4007 | MRA4007T3G | ON Semiconductor |
| 1 | D10 | DO-41 | | 1N4730A | Vishay |
| 2 | F1, F3 | 64600001003 | | 64600001003 | Littelfuse |
| | Fuse Holder | | | 64000001003 | Littelfuse |
| 1 | J1 | TB-1x4/3.5/15x7/Sc_H | V Select | 2828364 | TE Connectivity |
| 1 | J2 | TB-1x2/5/11x8/Sc_H | AC | 2828362 | TE Connectivity |
| 1 | J3 | 22-23-2021 | 22-23-2021 | 22-23-2021 | Molex |
| 1 | Mating Connector | | | 10-11-2023 | Molex |
| 2 | J4, J5 | 22-23-2041 | 22-23-2041 | 22-23-2041 | Molex |
| 2 | Mating Connector | | | 10-11-2043 | Molex |
| 1 | J6 | TB-1x4/5/21x8/Sc_H | | 2828364 | TE Connectivity |
| 1 | J7 | 55932-0410 | 55932-0410 | 55932-0410 | Molex |
| 1 | J8 | 22-23-2061 | 22-23-2061 | 22-23-2061 | Molex |
| 1 | Mating Connector | | | 10-11-2063 | Molex |
| 1 | J9 | HDR-1x6 | FTDI | 826646-6 | Molex |
| 1 | J10 | HDR-2x3T/2.54x2.54/8x5 | ICSP2 | 90131-0123 | Molex |
| 1 | J11 | I2C | 75869-131LF | 75869-131LF | FCI / Amphenol |
| 1 | Mating Connector | | | 71600-106LF | FCI / Amphenol |
| 1 | J12 | Speaker | 75869-132LF | 75869-132LF | FCI / Amphenol |
| 1 | Mating Connector | | 649-71600-108LF | 71600-108LF | FCI / Amphenol |
| 1 | J13 | 503159-0400 | | 503159-0400 | Molex |
| 1 | J14 | 22-23-2051 | 22-23-2051 | 22-23-2051 | Molex |
| 1 | Mating Connector | | | 10-11-2053 | Molex |
| 23 | Terminals | | | 08-50-0114 | Molex |
| 2 | K4, K5 | T90 SPST | | T90S1D12-12 | TE Connectivity |
| 1 | Q1 | SOT23 | 2N7002 | 2N7002 | ON Semiconductor |
| 1 | Q3 | SOIC-18/300mil | ULN2803 | ULN2803ADWR | Texas Instruments |
| 1 | R8 | RES-17.78/11.4x5.1 | 180R | 5093NW220R0J | Vishay |
| 5 | R3, R11, R12, R13, R25 | RES_1206 | 4k7 | ERJ-8ENF4701V | Panasonic |
| 6 | R5, R6, R10, R22, R32, R91 | RES_1206 | 10k | ERJ-8ENF1002V | Panasonic |
| 1 | R7 See Note 1 | SL22-20005 | SL22-20005 | SL22-20005 | Ametherm |

| | | | | | |
|---|----------------------------------|-----------------------|--------------|-------------------|-------------------|
| 1 | R7 See Note 1 | SL22-40005 | SL22-40005 | SL22-40005 | Ametherm |
| 7 | R9, R15, R17, R23, R24, R26, R29 | RES_1206 | 100R | ERJ-8ENF1000V | Panasonic |
| 2 | R14, R19 | RES_1206 | 220R | ERJ-8ENF2200V | Panasonic |
| 2 | R16, R18 | RES_1206 | 47R | ERJ-8ENF47R0V | Panasonic |
| 1 | R20 | RES_1206 | 2k2 | ERJ-8ENF2201V | Panasonic |
| 1 | R21 | RES_1206 | 430R | ERJ-8ENF4300V | Panasonic |
| 1 | T1 See Note 2 | L01-10 | L01-6341 | L01-6341 | Amgis, LLC |
| 1 | T2 See Note 2 | PL10 | PL10-20-130B | PL10-20-130B | Tamura |
| 1 | U1 | TO263-3(4)/15x10x2.54 | | MC7805CD2TR4G | ON Semiconductor |
| 1 | U2 | SOIC-8/150mil | PCA9536D | PCA9536D | Texas Instruments |
| 1 | U6 | SOIC-18/300mil | MCP23008 | MCP23008T-E/SO | Microchip |
| 2 | U8, U11 | SDIP-8 | HCPL2530 | HCPL-2530S | ON Semiconductor |
| 1 | U9 | QFP-32/9x9x0.8 | ATMEGA328 | ATMEGA328P-AU | Microchip |
| 1 | Y2 | CSTCE_V | CSTCE16M0V53 | CSTNE16M0V530000R | Murata |

Note 1 - the control boards are designed to operate at either 120VAC or 240VAC. Select the appropriate resistor to match your application.

Note 2 - Select your preferred transformer style L01-6341 is a potted toroidal transformer while PL10-20-130B is slightly lower cost split bobbin transformer.

Note 3 - This board has an optional error reporting circuit on it, but parts for this are not listed in the BOM. It also has extra connectors for speaker relay interconnection and I2C that aren't in the BOM.

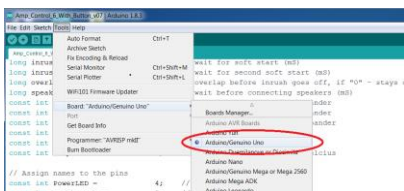
Note 4 – J3 is an Aux output that can be controlled via software to operate a remote device such as a relay. R2 must be selected to work with whatever is connected to this output.

A word of caution when ordering Atmega328 ICs, there are similar devices with a slightly different suffix. They are an automotive grade part and are usually slightly lower cost. They will not work with the Arduino IDE. They have different fuse bit settings that the IDE won't recognize, so it won't write the bootloader to it. Ensure you order Atmega328P-AU.

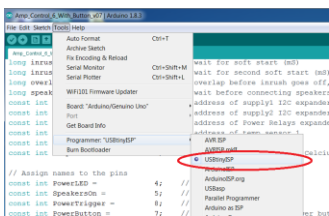
Assembly and Testing

The first parts that should be populated are the microcontroller and its associated parts needed to run. U9, Y2, R10, C9 and J10. Once these are in place, it's time to install the bootloader. To do this you will need a USBtinyISP programmer or similar tool. The bootloader is flashed with the Arduino IDE available for download from the Arduino website. <https://www.arduino.cc/en/Main/Software>

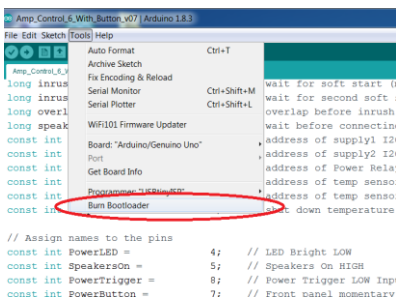
In the Arduino IDE, under tools, select Arduino Uno for board.



Select USBTinyISP for programmer.



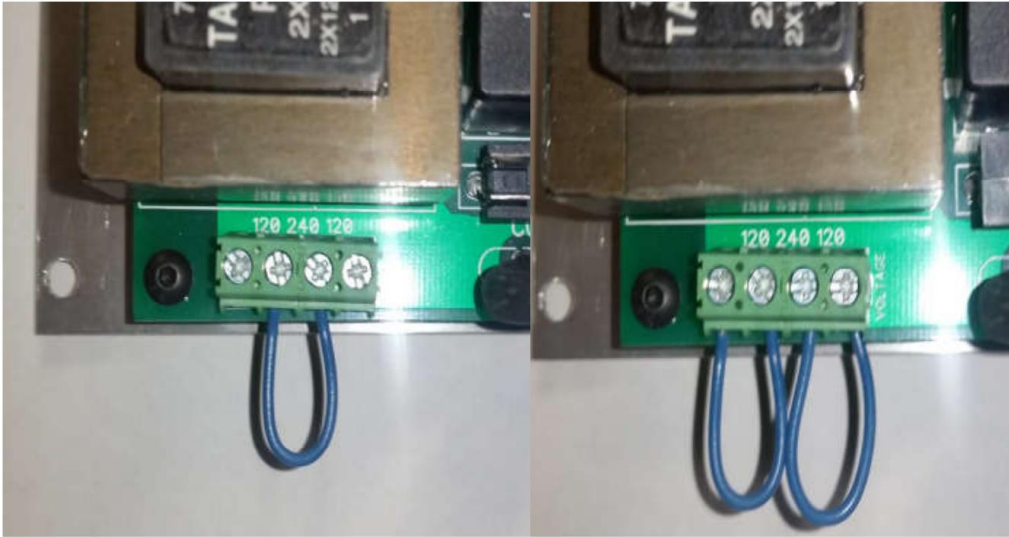
Connect the USBTinyISP with the 6-wire ribbon cable to the ISP2 header, paying attention to the location of pin 1. Under tools in the Arduino IDE, select burn bootloader.



The bootloader may load in a second or may take a minute to load, every computer writes this differently. Once it is successfully loaded, you are ready to proceed with building.

Next install all your smaller low-level parts, working your way up to the taller pieces until the board is fully assembled, checking for shorts and continuity as you go.

Next line voltage needs to be selected for the control transformer with J1. the terminal block is optional here. 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. Install a fuse for the control transformer in F1 and the board is ready to power up and load software.



240VAC Operation

120VAC Operation

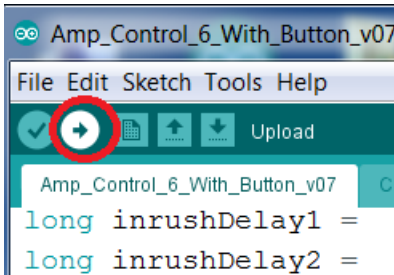
Loading the Software

The first software to load is a sketch called I2C scanner. To load the software, you will need a FTDI USB to serial adapter cable or other such adapter. The FTDI cable is designed to power the board from the USB power of the computer.



This isn't enough power to run the board while programming, so we remove the red wire (pin 3) from the adapter cable connector during programming.

You will need to install drivers for the serial adapter. FTDI drivers come in the Arduino IDE folder. With the I2C scanner sketch open, in the Arduino IDE under tools, you need to select Arduino Uno board again and also the port that the serial adapter cable is connected on (usually the last on the list). Hit the upload button, and let the software load.



This should take less than 30 seconds. Once upload is complete, open the serial monitor in the Arduino IDE. You should see

Scanning...

I2C device found at address 0x?? (There will be a 2-digit Hexadecimal value in place of the two question marks)

0x?? (Whatever digits are in place of the question marks) is the I2C address of your relay expander. Record this address for later. Next plug in each other device you are going to be connecting with I2C communication (temp sensors or supply boards) one at a time and record the new I2C address that appears in the serial monitor window. Once you have all your I2C addresses recorded, you are ready to proceed to prepare the software for loading.

Preparing the Software

```

; //compatibility with older versions of IDE - bugfix

#define DEBUG 1 //DEBUG 1 - we get all console output in the code
#define ERROR_REPORTING 0 // ERROR_REPORTING 1 - send binary messages to other devices

const int TubesAreHere = 0; // 1 = Tubes, 0 = NO Tube
const int Supply1IsHere = 1; // 1 = I2C supply is present
const int Supply2IsHere = 0; // 1 = 2nd I2C supply is present
const int temp1IsHere = 0; // 1 = heat sink temp sensor present
const int temp2IsHere = 0; // 1 = 2nd heat sink temp sensor present

long heatingDelay = 25000; // wait for tubes pre-heating (mS)
long inrushDelay1 = 1000; // wait for soft start (mS)
long inrushDelay2 = 3000; // wait for second soft start (mS)
long overlapDelay = 500; // overlap before inrush goes off, if "0" - stays on (ms)
long speakersDelay = 5000; // wait before connecting speakers (mS)
const int supply1Address = 0x27; // address of supply1 I2C expander
const int supply2Address = 0x3F; // address of supply2 I2C expander
const int relayAddress = 0x24; // address of Power Relays expander
const int temp1Address = 0x48; // address of temp sensor 1
const int temp2Address = 0x4D; // address of temp sensor 2
const int tempLimit = 80; // shut down temperature in Celcius

// Assign names to the pins
const int PowerLED = 4; // LED Bright LOW
const int SpeakersOn = 5; // Speakers On HIGH
const int PowerTrigger = 8; // Power Trigger LOW Input

Done compiling.

Sketch uses 6228 bytes (19%) of program storage space. Maximum is 32256 bytes.
Global variables use 630 bytes (30%) of dynamic memory, leaving 1418 bytes for local variables. Maximum is 2048 bytes.

```

“0” disables an option, “1” enables it.

`#define DEBUG 1` This selects whether or not the control board state changes are sent to the serial monitor console on your PC. Disable this and reload the software before putting the control board into service.

`#define ERROR_REPORTING 0` This selects whether or not you are using the error reporting service to an external data logging system.

`const int TubesAreHere = 0;` This is to select tube preheating delay for a tube hybrid design amplifier.

`const int Supply1IsHere = 0;` If you are using a supply with quick shut down rails, enter 1, otherwise enter 0.

`const int` Supply2IsHere = 0; If you are using a second supply with quick shut down rails, enter 1, otherwise enter 0.

`const int` temp1IsHere = 1; If you are installing a I2C temperature sensor, enter 1

`const int` temp2IsHere = 1; If you are installing a second I2C temperature sensor, enter 1

`const int` debugEnabled = 1; If this is enabled, you can watch operation of the power up sequence and see temperature readings in the serial monitor window. This should be disabled when the amplifier is put into service.

`long` heatingDelay = 25000; This is tube pre-heating delay in milliseconds. This is disabled if TubesAreHere = 0; was selected in the first line.

`long` inrushDelay1 = 1000; This is the length of delay in milliseconds between the first inrush relay engagement and the second.

`long` inrushDelay2 = 3000; This is the second inrush delay. This value can be adjusted shorter. Minimum time length should be the length of time it takes for the second supply to reach 90% of full charge.

`Long` overlapDelay = 500; This is the amount of time between when the power relay engages and the inrush relay disengages

`Long` speakersDelay = 5000; This is the delay between power on and speaker relay engagement. This can be shorter, but it's necessary to wait until the amplifier has settled and DC offset has dropped to a minimum, otherwise the DC offset may be triggered, or you may hear a turn on pop through the speaker.

`const int` supply1Address = 0x27; If you are using a supply with quick shut down rails, enter the address here, otherwise ignore this.

`const int` supply2Address = 0x3F; If you are using a second supply with quick shut down rails, enter the address here, otherwise ignore this.

`const int` relayAddress = 0x24; Enter your relay expander address (the first address you saw in the serial monitor window)

`const int` temp1Address = 0x48; Enter the address of your temperature sensor here.

`const int` temp2Address = 0x4D; If you are using two temperature sensors enter the address of your second temperature sensor here.

`const int` tempLimit = 80; Enter the shutdown temperature of the amplifier in Celsius.

Software is ready to run, load it on as you did the I2C Scanner sketch.

Testing Continued

The Amp Control board should now be operational. Connect a LED to the LED header and install a jumper on pin 1-2 of J8 header. Relays should be heard engaging.

Over-current protection can be tested by applying voltage to the bias connector. Pin 1 is the positive input for 1 channel, pin 2 negative. Pin 4 is positive for the other channel, pin 3 negative. Over-current protection should be activated around 2.4V, at which time the relays should click off, and the LED will begin flashing. The control board will now stay locked off until power is disconnected, and reconnected, or the reset button is pushed.

Temperature sensor operation can be verified by watching the serial monitor window. Apply heat to the temperature sensor(s) and watch the reading climb until it reaches its shut down point, at which time the relays should click off, the serial monitor window will stop scrolling, and the LED should be flashing a trouble code.

Power loss detection is hard to physically test. You would need to interrupt mains power and reconnect it before the supply cap for the microcontroller drains low enough to cause it to reboot. To simulate a loss of voltage momentarily short pin 1 and pin 2 on U11. This circuit is current limited, so shorting it won't damage anything. Again, the relays should click off and the LED will start flashing a trouble code.

DC Detection can be tested by connecting a DC Detection board without rail voltage attached to it. This should trigger a DC fault shut down.

If all is operating properly, the Amp Control board is ready for final software install (disable debugging) and is ready for service.

Error reporting

The amp control board will announce every change in state as it runs through it's start-up sequence as well as in the event of a shutdown for any reason. These events are sent out as a 4-bit binary code written though analog pins A0 - A3. There is also a state change enunciator pin available at pin 1 of the Data I2C connector (J14). The error reporting codes are as follows in LSB format.

Error code protocol

0000 - off

0001 - tube preheat

0010 - 1st supply inrush

0011 - second supply inrush

0100 - power on

0101 - inrush off

0110 - speakers on

0111 -

1000 - DC Offset

1001 - overload

1010 - AC Failure

1011 - overTemp 1

1100 - overTemp 2

1101 -

1110 - power button pushed

1111 - remote trigger changed state

These error codes are read by a port expander (U2) and converted to MSB in I2C format. The port expander is powered through the Error Report connector. The expander will operate on either 5V or 3V3. This allows the communication to be at whatever the data logging controller happens to be, eliminating the need for level shifting. The state change enunciator is powered by this connector as well, so it will operate at the data logging controller's native voltage as well.

Installing the board

All necessary fusing for the amplifier is on the Amp Control board, so no rear panel fuses are required. Connect mains power to the AC connector. Connect the main supply inlet leads of the transformer to J6. The transformer hot leads go to 1 and 2, neutral to 3 and 4. For 240V operation with dual input windings, series connection between windings needs to be done externally. Auxiliary controlled 12V devices can be connected to J3, pin 1 being switched negative, pin 2 12V.

Pin 1 and 2 of J8 header are connected to the front panel power switch. Pin 3 and 4 go to an optional rear panel shorted contact trigger connector. Pin 5 and 6 go to an optional rear panel 12V trigger connector, pin 5 being positive.

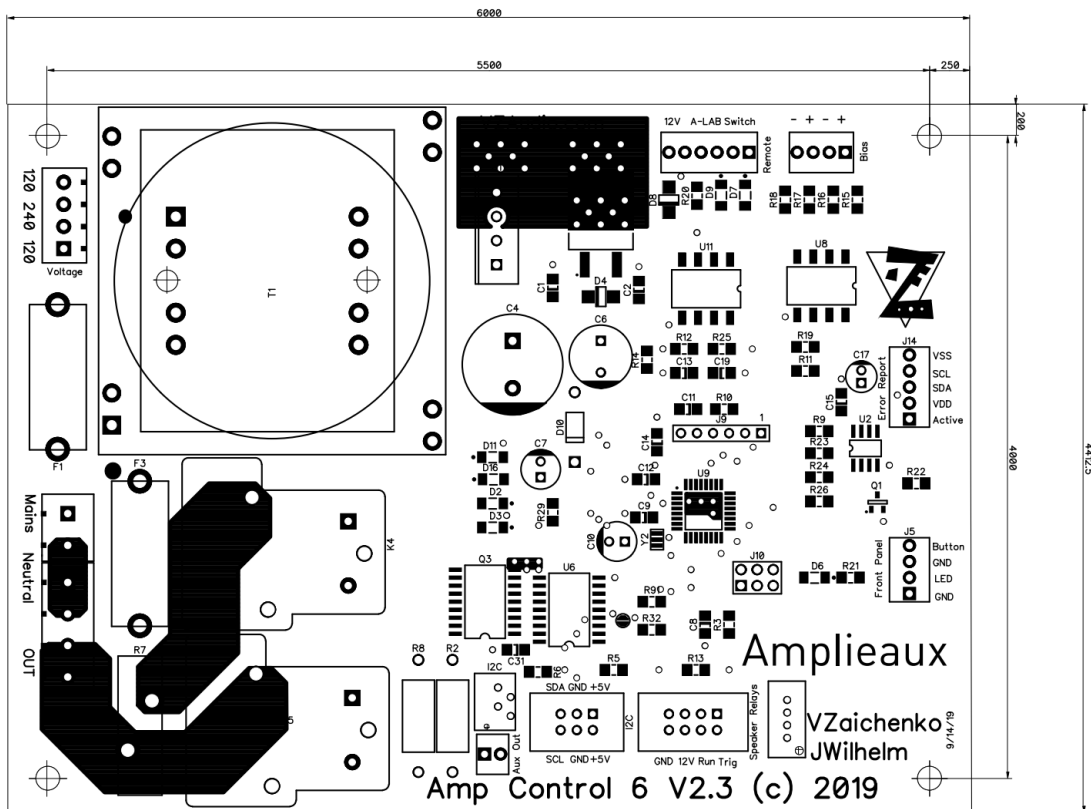
Pin 1 and 2 of the Bias header connect to the transistor side of a pair of emitter resistors on one amp channel, pin 1 to the positive rail transistor. Pin 3 and 4 connect to the other channel, pin 3 being positive.

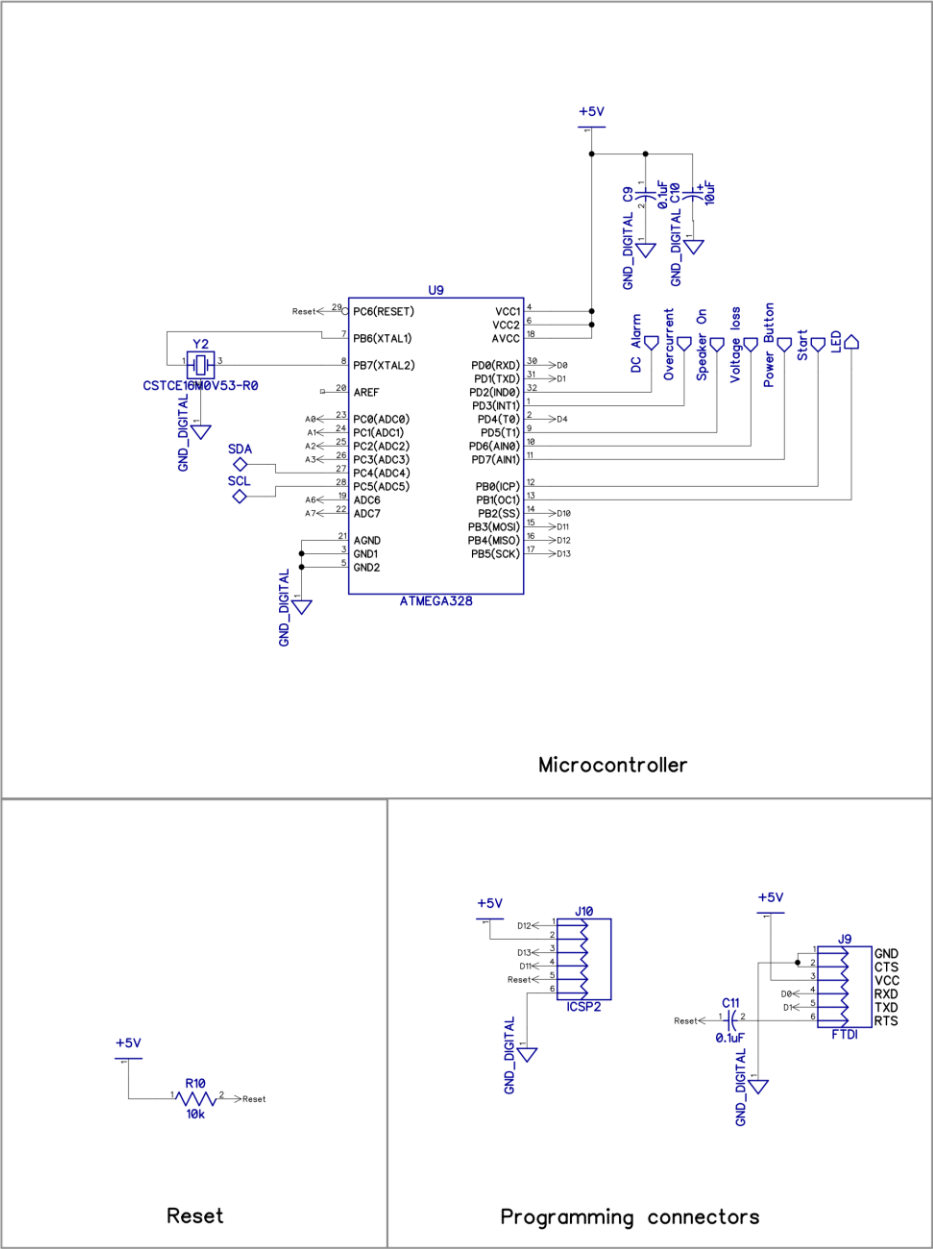
Pin 1 & 2 of the LED header is connected to the front panel LED. Pins 3 & 4 connect to a momentary front panel push button for power on/off which will be overridden by the rear panel triggers for on.

The Speaker Relays connector is attached to all DC detection boards (or amplifier boards with integrated protection) on a single 8 wire ribbon cable. Plan your routing to keep this as neat as possible.

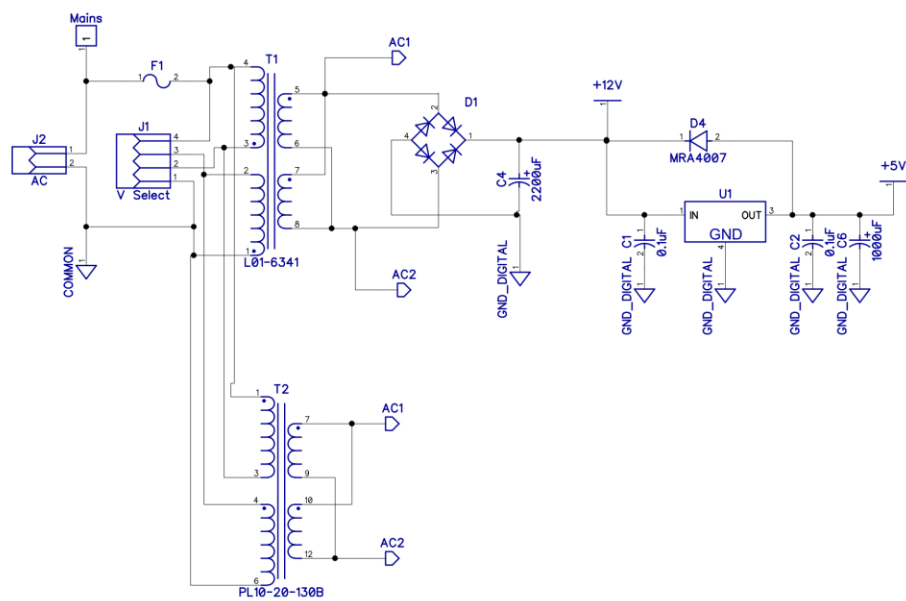
The I2C connects to all I2C devices on a single 6 wire ribbon. Again, plan this routing to keep it neat.

The Amp control board is now ready for operation.

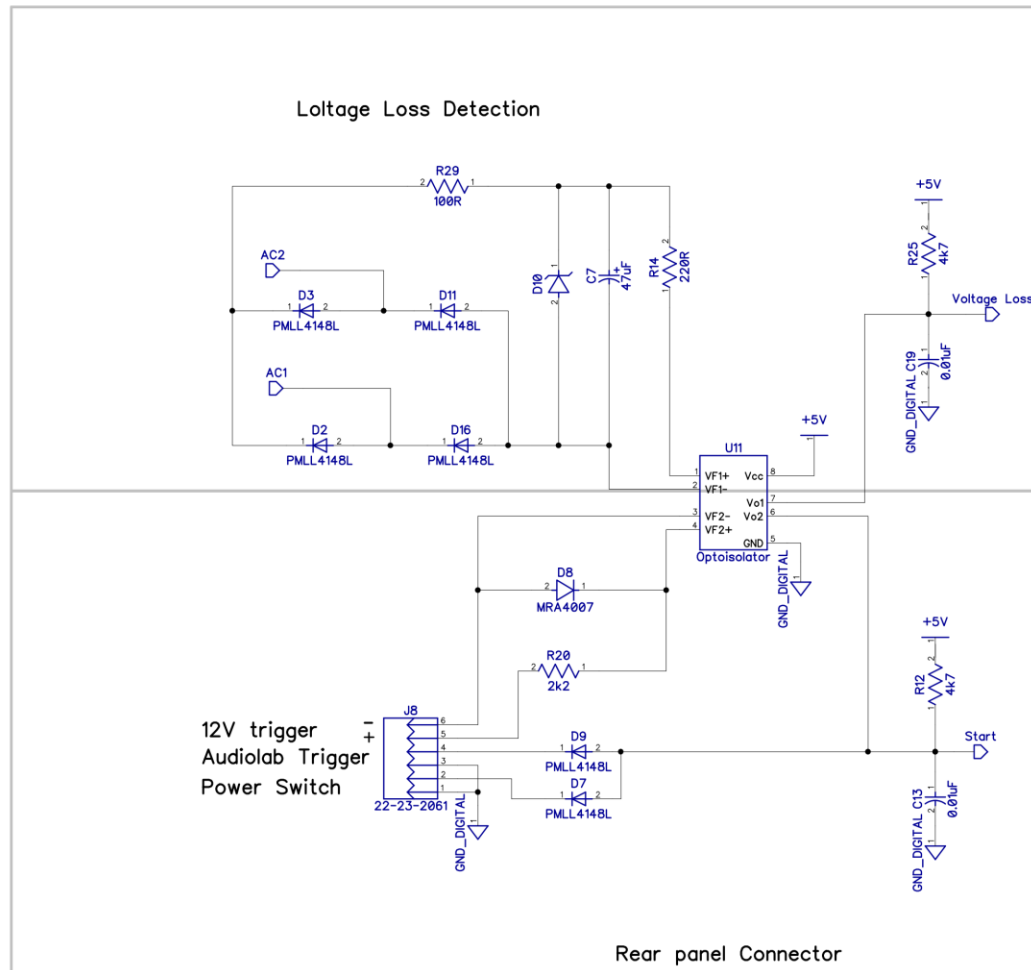




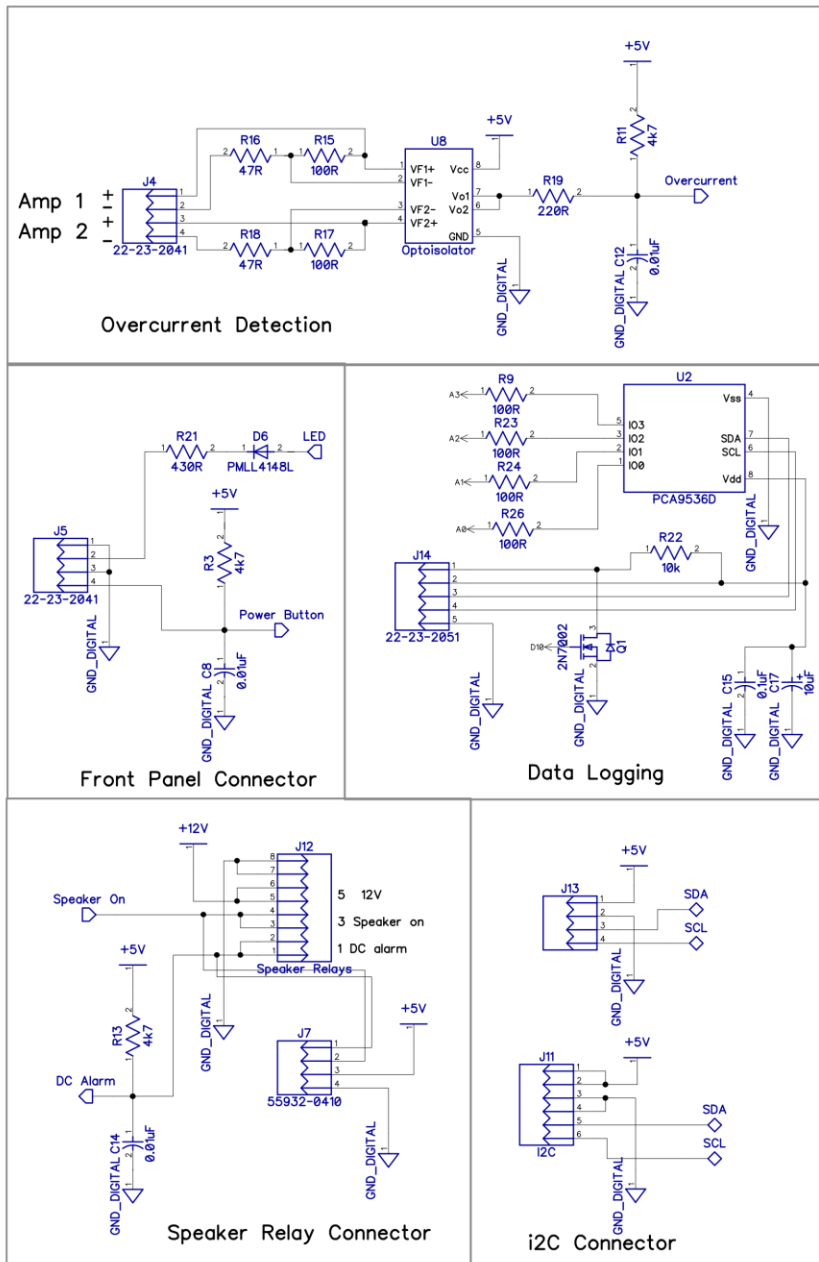
Brains



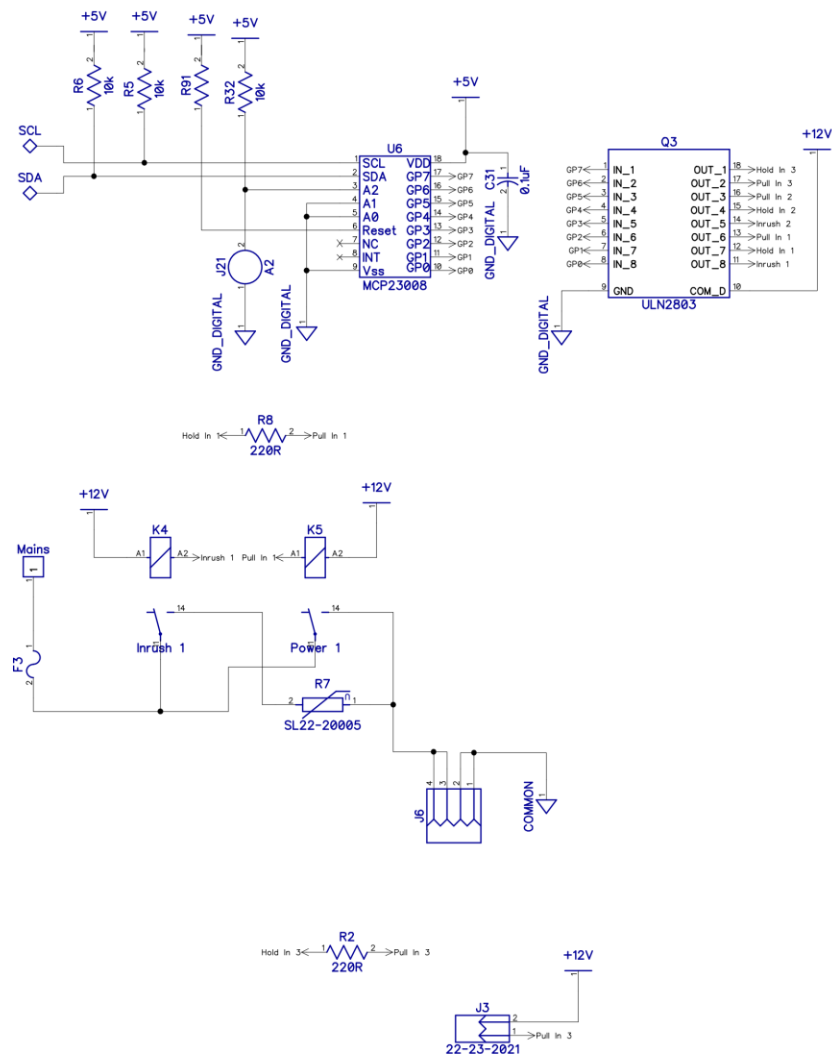
Supply



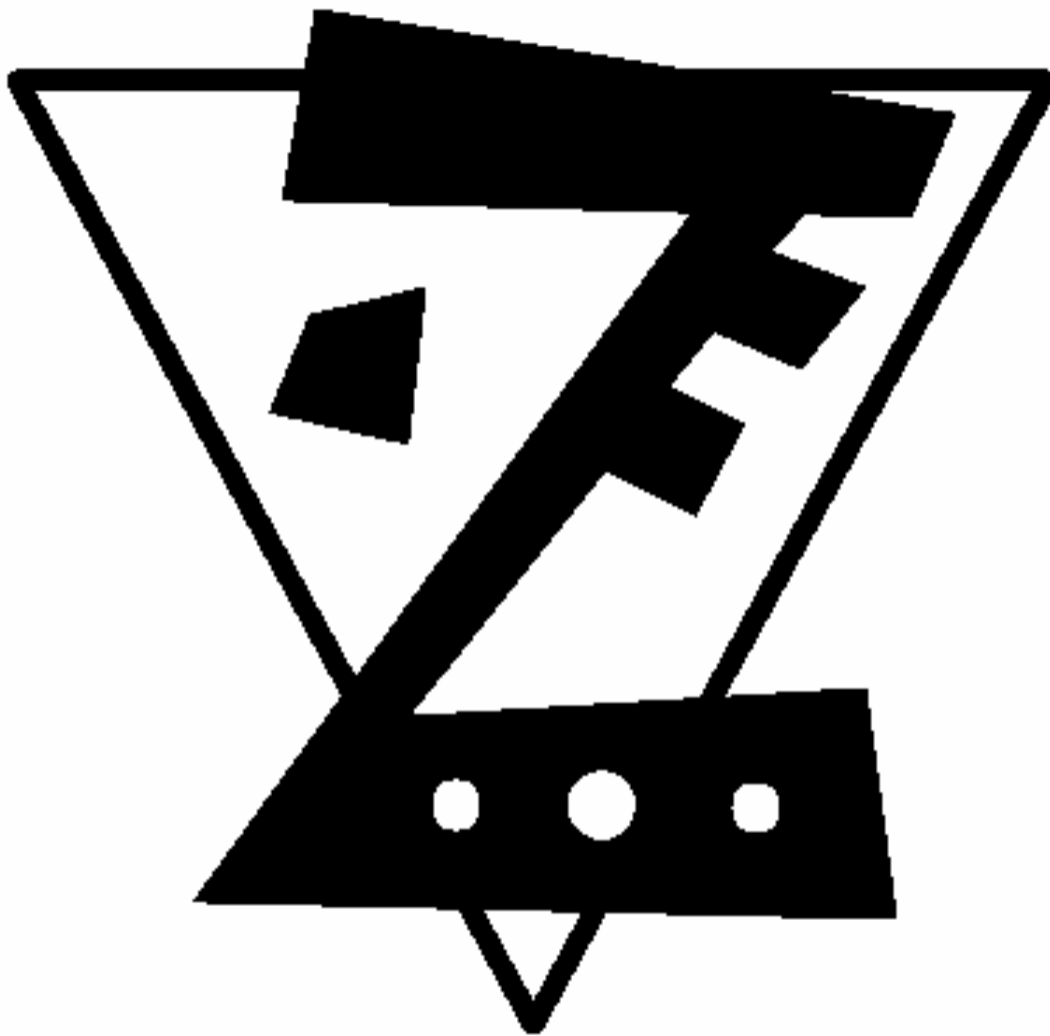
Voltage loss detection and start



Sensors



Relays



<http://www.vzaudio.com/>