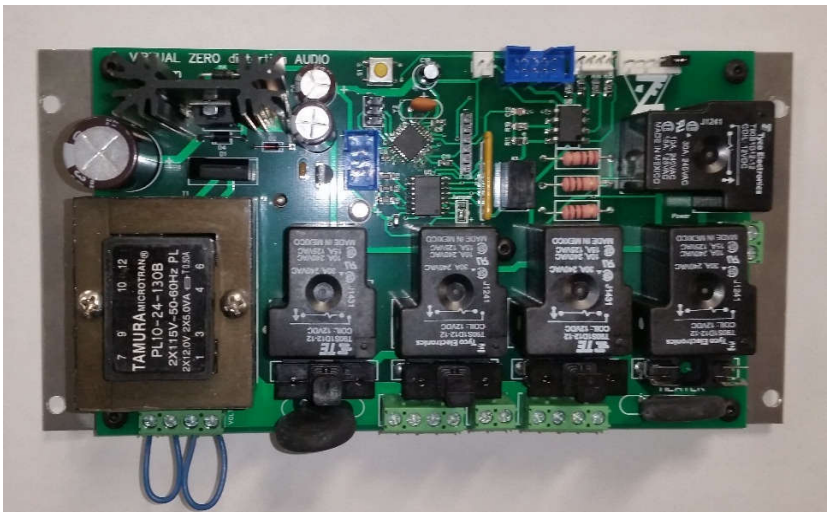
Amp Control V5.1



Amp control V5.1 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.

It has on board current sensing connections that monitor the voltage drop through a pair of emitter resistors of up to two amplifier channels. It monitors temperature of up to 8 locations with remote temperature sensors connected over an I2C communication bus. It has a connector that is daisy chain connected to multiple DC detection board/speaker relays. It has five on board power relays and fusing that will start and protect two main power transformers and an auxiliary transformer for an amplifier. It can 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. It has an on board mains voltage loss detection circuit to protect the supply transformer from brown outs and intermittent power loss. It has an input for a front panel switch, as well as a 12VDC trigger input and a shorted contact trigger input to signal power up. It controls a front panel LED that will signal power state and will flash trouble codes if a shutdown event happens. It's expandable through communication over I2C, SPI or serial communication for just about any other imaginable interface need.

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 softstart sequence. It first engages an on board inrush relay that powers one main supply transformer through an on board NTC resistor. Next it engages main power relays. If supplies with rail quick shut downs are connected, they are sent an on signal over I2C. After a programmed delay, DC detection monitoring begins, after which the speaker relays are engaged. 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.

BOM

Qty	RefDes	Name	Value
1	C1	16x25x7.5	2200uF
5	C2, C3, C4, C15, C16	CAP_1206	.1uF
2	C5, C6	10x12x5	1000uF
4	C8, C9, C11, C17	CAP_0805	.1uF
2	C10, C18	6.3x11x2	10uF
4	C12, C13, C14, C7	CAP_1206	.01uF
1	D1	2KBP02	2KBP02
1	D2	Zener	BZX55C5V1
5	D3, D6, D7, D8, D9	PMLL4148L	PMLL4148L
2	D4, D5	1N4007	1N4007
4	F1, F2, F3, F4	FUSE 22.86 vz	64600001003
3	J1, J6, J7	282836-4	
2	J2, J13	282836-2	
1	J4	HDR-1x4	Bias
1	J5	HDR-1x2	LED
1	J8	HDR-1x6	Start
1	J9	HDR-1x6	FTDI
1	J10	90131-0123	ICSP2
1	J11	75869-132LF	I2C
1	J12	75869-131LF	Speaker
1	K1	TSC-112D3H	TSC-112D3H
2	K2, K4	T90 Relay	Inrush
3	K3, K5, K6	T90 Relay	Power
2	Q1, Q2	ULN2003D	ULN2003D
2	R1, R7	71.1581	SL22-20005
5	R2, R11, R12, R13, R22	RES_1206	4k7
1	R3	4308R-1	47k
3	R4, R8, R14	RES700	320R
2	R5, R6	RES_1206	10k
1	R9	RES_1206	47k
1	R10	RES_1206	10k

2	R15, R17	RES_1206	100R
2	R16, R18	RES_1206	47R
1	R19	RES_1206	220R
1	R20	RES_1206	2k2
1	R21	RES_1206	430R
1	S1	Reset Switch	B3SL-1002P
1	T1	PL10-10-130B	PL10-10-130B
1	U3	LM7812CT	LM7812
1	U4	LM7805CT	LM7805
1	U5	PCF8574	PCF8574
1	U7	TC54_ZB	TC54VC3002EZB
2	U8, U11	Optoisolator	HCPL2530
1	U9	Atmega328P-AU	Atmega328P
1	Y2	ECS-73-20-4-3IL	HC49S

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. The 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.

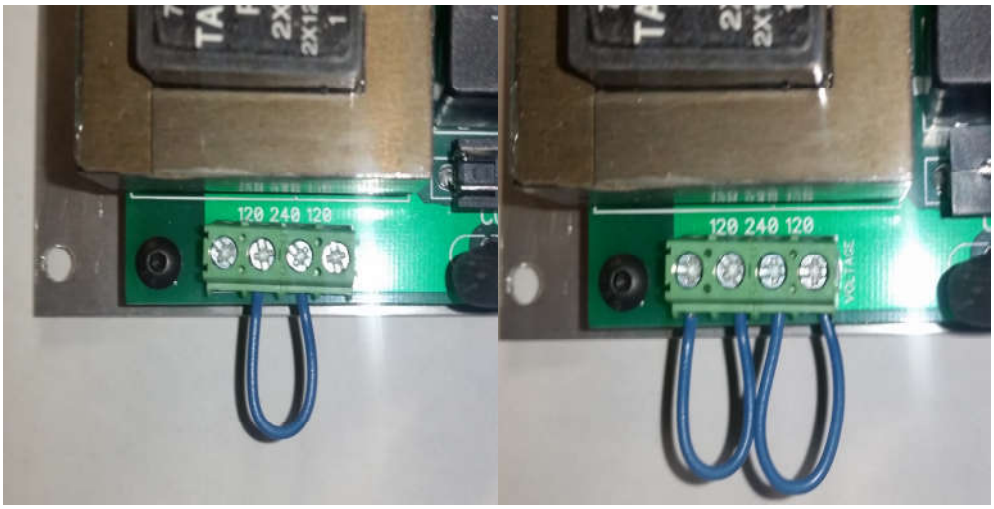
Assembly and Testing

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, and 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. 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. When installing U5 you will need to set its I2C address by soldering either pin 1 and 2, or pin 2 and 3 together on J3 jumper. It doesn't matter which jumpers you choose, and no need to even remember which one you did.

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. 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 able 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.

```
  linear gain lab 2014.12.20
  Modified for I2C controls 2012.3.14
*/

#include <Wire.h>

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


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 =    0x23;    // address of supply1 I2C expander
const int supply2Address =    0x3F;    // address of supply2 I2C expander
const int relayAddress =      0x39;    // 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
```

Preparing the Software

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

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 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 = 0x23; If you are using a supply with quick shut down rails, enter the address here, otherwise ignore this.

const int supply2Address = 0x23; If you are using a second supply with quick shut down rails, enter the address here, otherwise ignore this.

const int relayAddress = 0x39; 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 = 0x48; 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.

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

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. Measure voltage across C7. It should be above 4V. Shorting pin 2 to pin 3 on U7 should trigger a voltage loss shutdown. This circuit is current limited, so shorting it won't damage anything.

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.

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 transformer inlet leads of one transformer to J6, the other transformer to J7. 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. Heater transformer connections are made at J13, 1 being neutral, 2 being hot.

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.

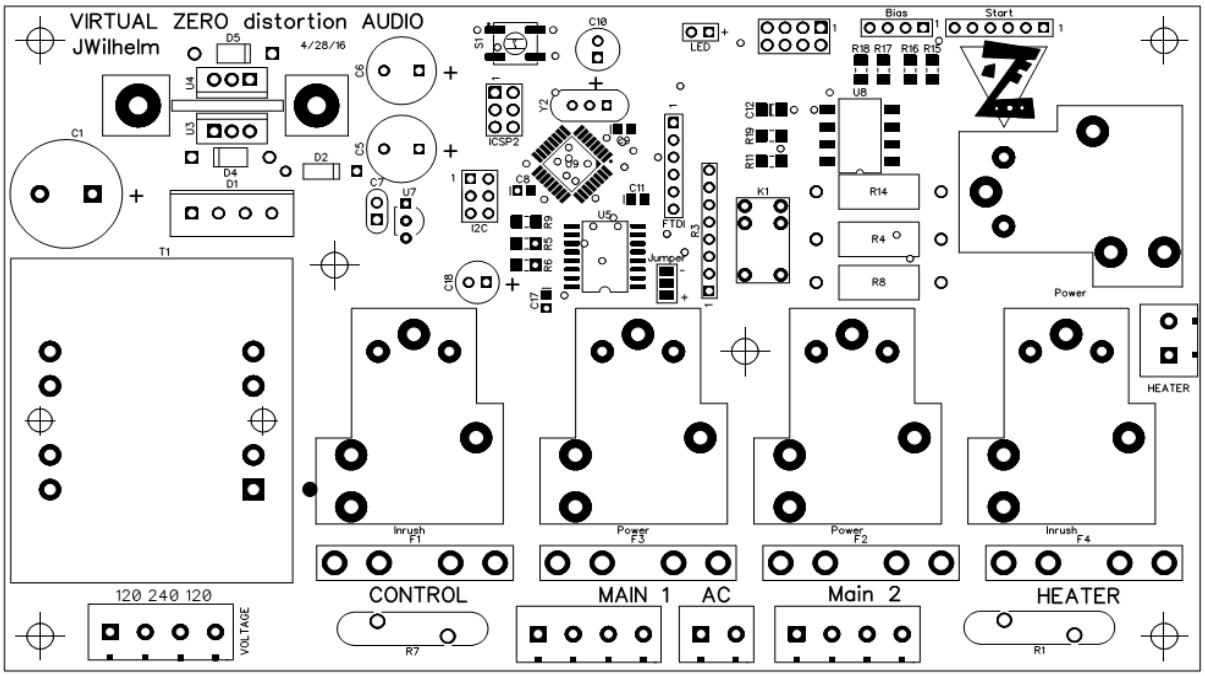
Pin 1 and 2 of the Bias header connect to the transistor side of a pair of emitter resistors on one amp channel, pin 1 to the positive rail transistor. Pin 3 and 4 connect to the other channel, pin 3 being positive.

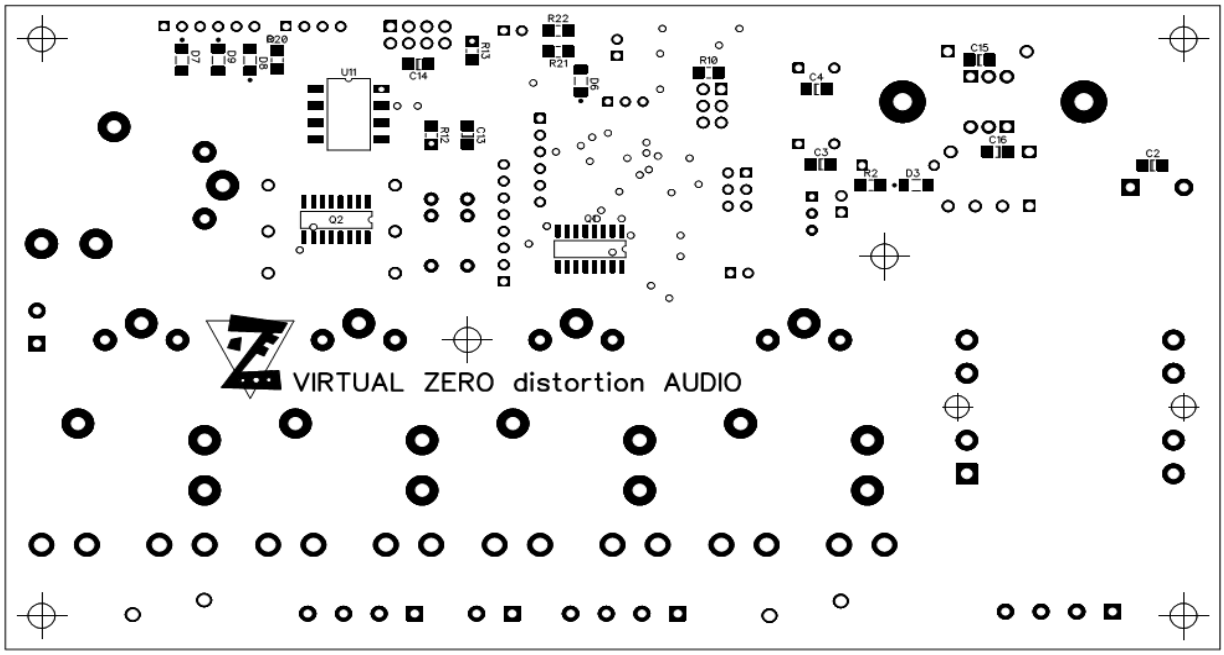
The LED header is connected to the front panel LED.

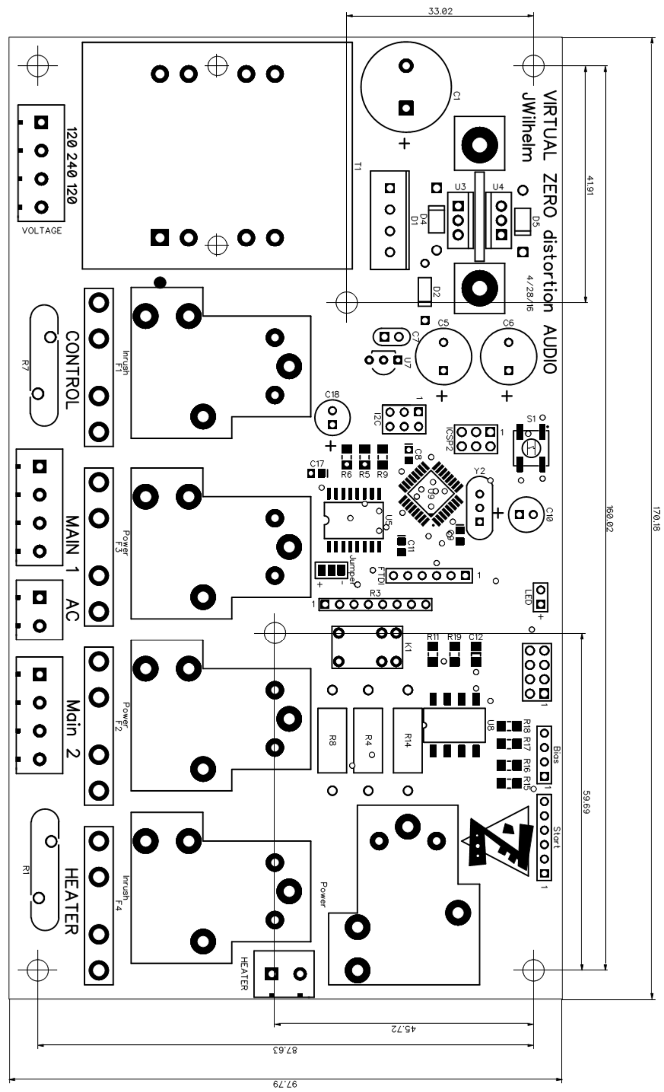
The Speaker connector is attached to all DC detection boards on a single 8 wire ribbon cable. Plan your routing to keep this as neat as possible.

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.


VIRTUAL ZERO distortion AUDIO
JWilhelm
4/28/16
Bias
Start
Power
HEATER
Inrush
F1
Power
F3
Power
F2
Inrush
F4
CONTROL
MAIN 1 AC
Main 2
HEATER
120 240 120
VOLTAGE
R7
R1


VIRTUAL ZERO distortion AUDIO


VIRTUAL ZERO distortion AUDIO
JWilhelm
4/28/16
120 240 120
VOLTAGE
CONTROL
MAIN 1
AC
Main 2
HEATER
33.02
41.91
160.02
170.18
59.69
45.72
87.63
97.79