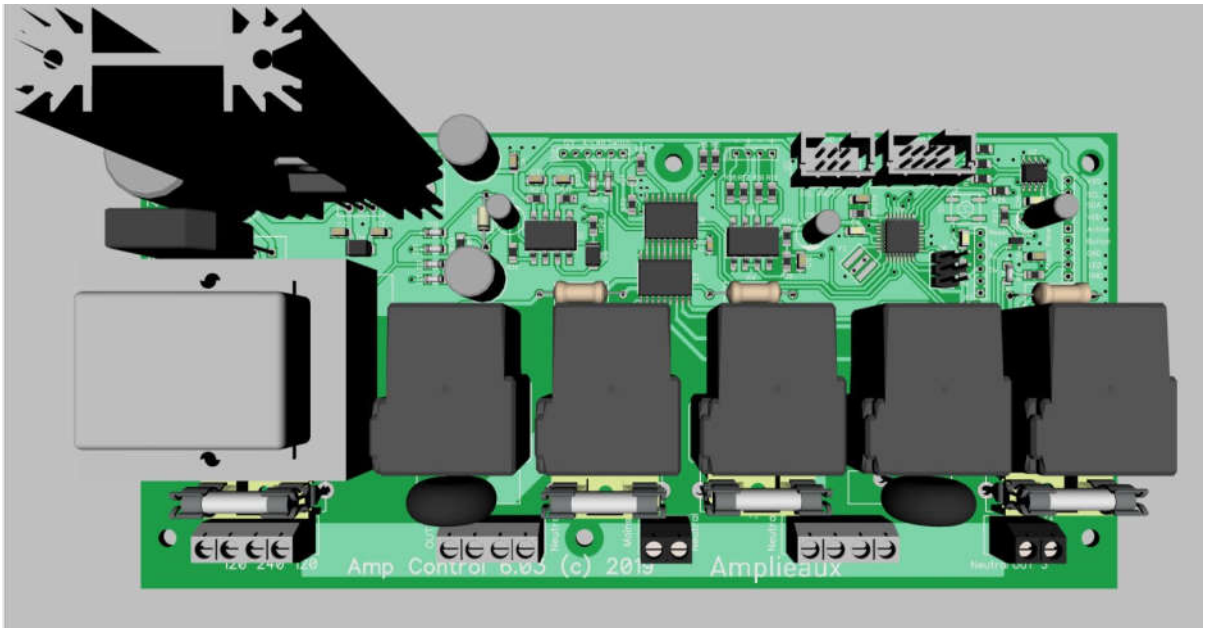
Amp Control 6.03

Control Board Building instructions

AMPLIEAUX

Version 6.03.1, June 2019



Amp Control 6 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 two main power transformers and an auxiliary transformer for an amplifier.

- 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. After a 1 second (adjustable) delay it powers the second main supply transformer. 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 air a few different ways to solder parts to the boards. Reflow ovens of 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	Value	Name	Mouser	Digikey
1	C1	2200uF	16x25x7.5	647-UVZ1V222MHD	493-1323-ND
7	C2, C3, C4, C9, C11, C15, C16,	0.1uF	CAP_1206	80-C1206C104K1R	399-1805-1-ND
2	C5, C6	1000uF	10x12.5x5	647-UVZ1V102MHD	493-1322-ND
1	C7	47uF	6.3x11x2	647-UPW1E470MDD	493-11352-1-ND
5	C8, C12, C13, C14, C19	0.01uF	CAP_1206	80-C1206C103K1R	399-1236-1-ND
1	C10	10uF	6.3x11x2	647-UVZ1E100MDD1TD	493-13450-1-ND
1	C17	10uF	5x11x2	78-BZX55C5V1	BZX55C5V1GITR-ND
1	C31	0.1uF	CAP_0805	80-C0805C104K1R	399-3486-1-ND
1	D1	2KBP02	SIP-4/17.5x6.8x3.8	625-2KBP02M-E4/51	2KBP02M-E4/51GI-ND
7	D2, D3, D6, D7, D9, D10, D11, D16	PMLL4148	SOD-80	771-PMLL4148L-T/R	568-1749-1-ND
3	D4, D5, D8	MRA4007	403D-02	863-MRA4007T3G	MRA4007T3GOSCT-ND
1	D10	1N4730	DO-41	78-1N4730A	1N4730AGICT-ND
4	F1, F2, F3, F4	64600001003	Fuse Holder	576-64600001003	WK6244-ND
4	F1, F2, F3, F4	64000001003	Fuse Cover	576-64000001003	
1	J1	282836-4	Voltage Selector	571-2828364	A98078-ND
2	J2, J3	.200 Terminal block	AC, Tube	571-2828362	A98076-ND
2	J4, J5	.100" header	Bias, Front panel	538-22-23-2041	WM4202-ND
2	J6, J7	.200 Terminal block	Supply transformers	571-2828364	A98078-ND
1	J8	.100" header	Start	538-22-23-2061	WM4204-ND
1	J9	.100" header	FTDI	571-826646-2	WM50016-36-ND
1	J10	ICSP2	2 x 3 .100" header	538-90131-0123	WM8121-ND

1	J11	75869-131LF	I2C	649-75869-131LF	649-75869-131LF
1	J12	75869-132LF	Speaker	649-75869-132LF	609-3530-ND
1		Mating connector	71600-108LF	649-71600-108LF	609-3569-ND
1	J14	Data I2C	Data I2C	538-22-23-2051	WM4203-ND
5	K1,K2,K3,K4,K5	T90 Relay	T90S1D12-12	655-T90S1D12-12	PB110-ND
1	Q1	2N7002	SOT23	512-2N7002	2N7002LDKR-ND
1	Q3	ULN2803	SOIC-18/300mil	595-ULN2803ADWR	296-15777-1-ND
2 *	R1, R7 120VAC	SL22-20005	20R NTC	995-SL22-20005	570-1139-ND
2 *	240VAC Operation	SL22-40005	40R NTC	995-SL22-40005	570-1049-ND
3	R2, R4, R8	220R	RES-17.78/11.4x5.1	594-5093NW220R0J	PPC220W-3JCT-ND
5	R3, R11, R12, R13, R25	4k7	RES_1206	667-ERJ-8ENF4701V	P4.70KFCT-ND
6	R5, R6, R10, R22, R32, R91	10k	RES_1206	667-ERJ-8ENF1002V	P10.0KFCT-ND
7	R9, R15, R17, R23, R24, R26, R29	100R	RES_1206	667-ERJ-8ENF1000V	P100FCT-ND
2	R16, R18	47R	RES_1206	667-ERJ-8ENF47R0V	
2	R14, R19	220R	RES_1206	667-ERJ-8ENF2200V	P220FCT-ND
1	R20	2k2	RES_1206	667-ERJ-8ENF2201V	P2.20KFCT-ND
1	R21	430R	RES_1206	667-ERJ-8ENF4300V	P430FCT-ND
1	S1	B3SL-1002P	B3SL	653-B3SL-1002P	SW1064CT-ND
1	T1	PL10	Transformer	838-PL10-24-130B	MT3127-ND
1	Heatsink			532-531302B25	HS386-ND
1	U2	PCA9536D	SOIC-8/150mil	595-PCA9536D	296-33496-5-ND
1	U3	LM7812	TO-220	512-LM7812ACT	LM7812CTFS-ND
1	U4	LM7805	TO-220	512-LM7805ACT	LM7805ACT
1	U6	MCP23008	SOIC-18/300mil	579-MCP23008T-E/SO	MCP23008T-E/SOCT-ND
2	U8, U11	HCPL2530	SDIP-8	512-HCPL-2530S	HCPL2530S-ND
1	U9	ATMEGA328	QFP-32/9x9x0.8	556-ATMEGA328P-AU	ATMEGA328P-AU-ND
1	Y2	Resonator	AWSCR-16.00MTD-T	815-AWSCR-16.00MTD-T	535-9362-1-ND
		6 conductor ribbon	HF365/06SF	517-HF365/06SF	MD06R-5-ND
		8 conductor ribbon	HF365/08SF	517-HF365/08SF	MD08R-5-ND

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

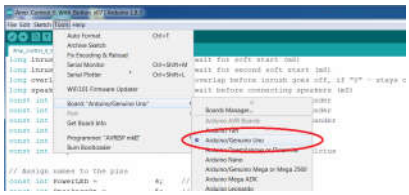
Note 2 - Digikey offers the ribbon cables in cut lengths. The Digikey part numbers listed are in 5' lengths. As an alternative, 8 lead cable can be used for both, simply remove two leads for the 6 conductor requirements.

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.

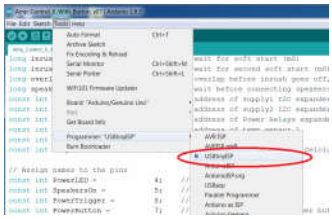
Assembly and Testing

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

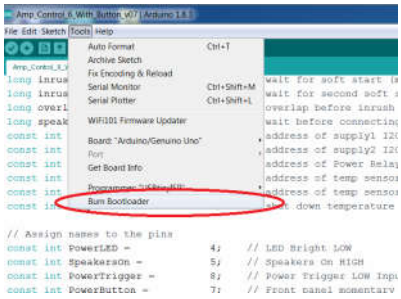
In the Arduino IDE, under tools, select Arduino Uno for board.



Select USBTinyISP for programmer.



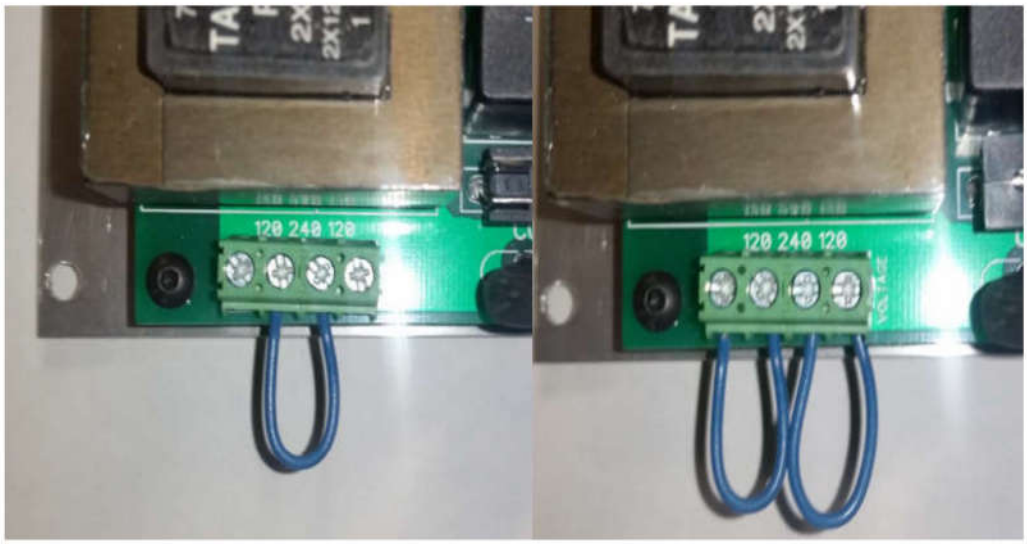
Connect the USBtinyISP with the 6 wire ribbon cable to the ISP2 header, paying attention to the location of pin 1. Under tools in the Arduino IDE, select burn bootloader.



The bootloader may load in a second, or may take a minute to load. 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.



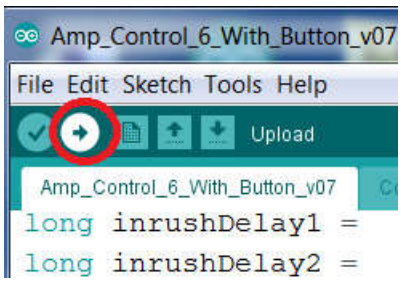
240VAC Operation ***120VAC Operation***

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 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

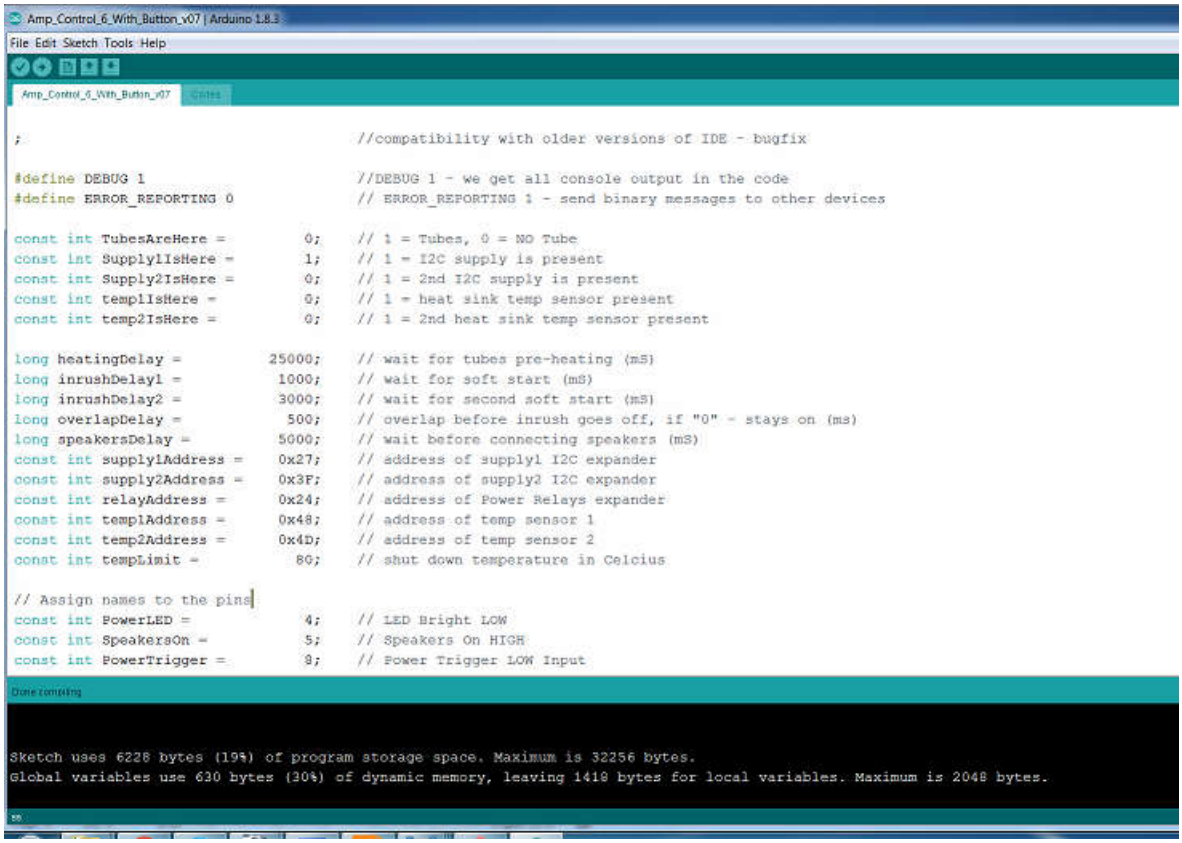
Scanning…

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.

Preparing the Software



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

#define DEBUG 1 This selects weather 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 weather 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 DataI2C connector. The expander will operate on either 5V or 3V3. This allows the communication o 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 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.

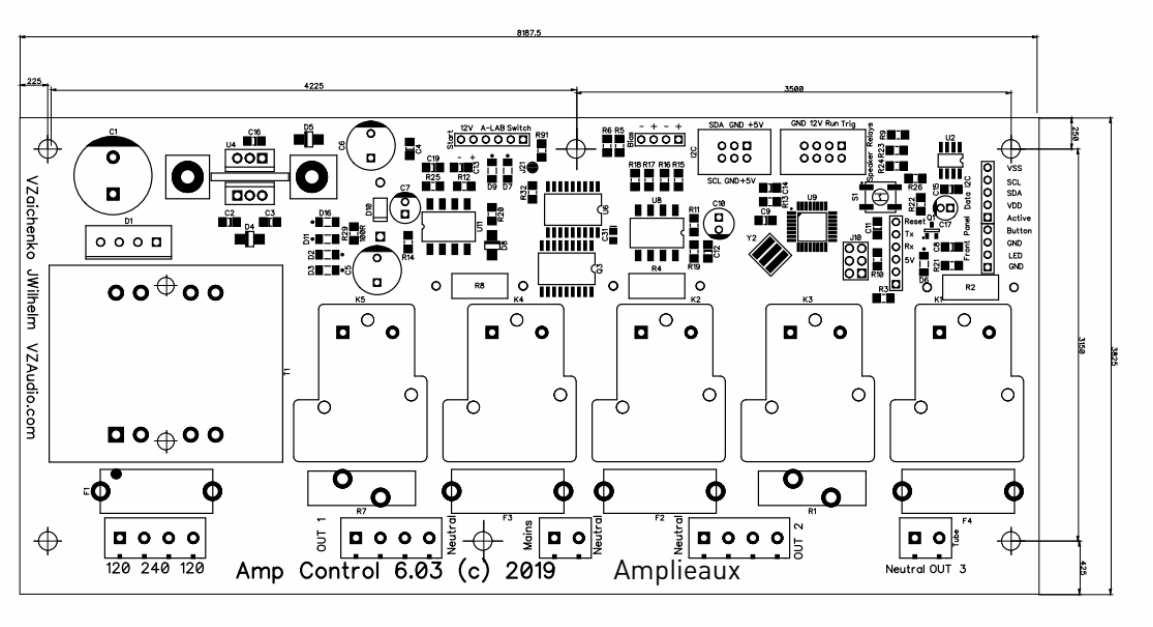
Pin 1 and 2 of the Bias header connect to the transistor side of a pair of emitter resistors on one amp channel, pin 1 to the positive rail transistor. Pin 3 and 4 connect to the other channel, pin 3 being positive.

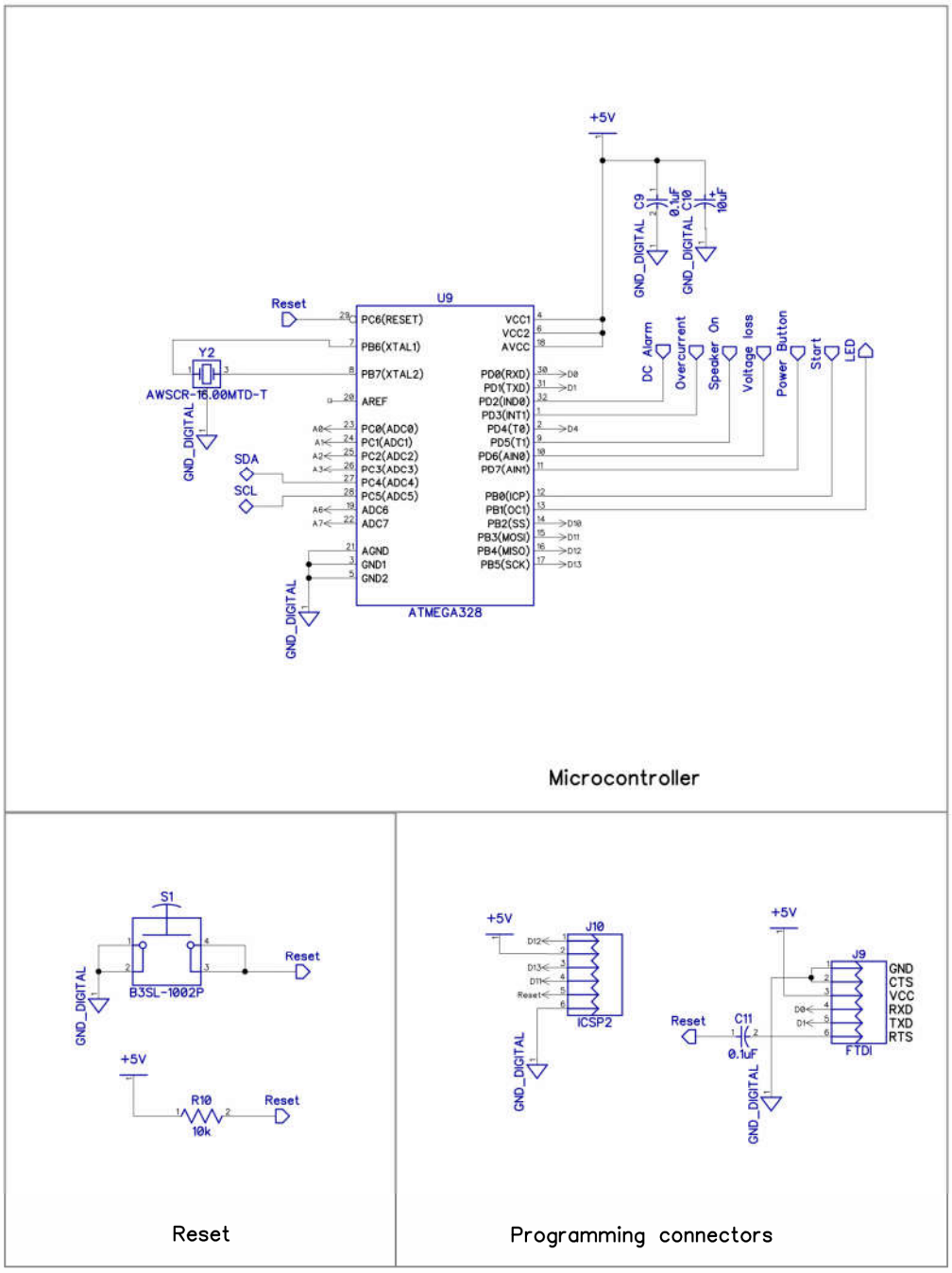
Pin 1 &2 of the LED header is connected to the front panel LED. Following a soon to be written software update pins 3 & 4 will connect to a momentary front panel push button for power on/off which will be overridden by the rear panel triggers for on.

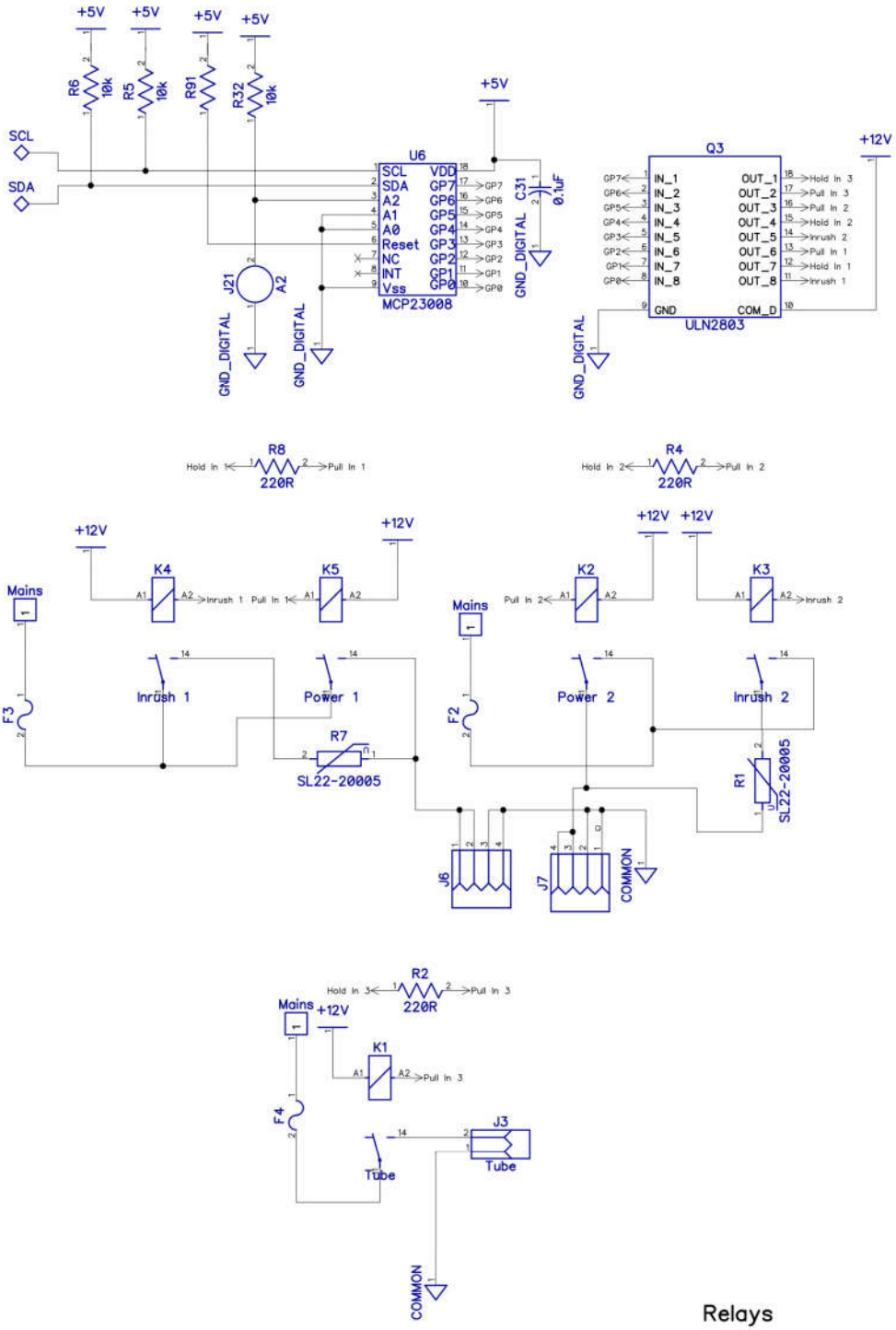
The Speaker Relays connector is attached to all DC detection boards (or amplifier boards with integrated protection) on a single 8 wire ribbon cable. Plan your routing to keep this as neat as possible.

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.


8187.5
225
4225
3500
VZaichenko JWilhelm VZAudio.com
120 240 120
Amp Control 6.03 (c) 2019
Amplieaux
OUT 1
OUT 2
Neutral OUT 3
Neutral
Mains
12V A-LAB Switch
SDA GND +5V
SCL GND+5V
GND 12V Run Trig
Speaker Relays
Front Panel Data I2C
VSS
SCL
SDA
VDD
Active
Button
GND
LED
GND
Reset
Tx
Rx
5V


+5V
C9
0.1uF
C10
10uF
GND_DIGITAL
U9
Reset
PC6(RESET)
PB6(XTAL1)
PB7(XTAL2)
AREF
PC0(ADC0)
PC1(ADC1)
PC2(ADC2)
PC3(ADC3)
PC4(ADC4)
PC5(ADC5)
ADC6
ADC7
AGND
GND1
GND2
VCC1
VCC2
AVCC
PD0(RXD)
PD1(TXD)
PD2(IND0)
PD3(INT1)
PD4(T0)
PD5(T1)
PD6(AIN0)
PD7(AIN1)
PB0(ICP)
PB1(OC1)
PB2(SS)
PB3(MOSI)
PB4(MISO)
PB5(SCK)
ATMEGA328
Y2
AWSCR-16.00MTD-T
SDA
SCL
DC Alarm
Overcurrent
Speaker On
Voltage loss
Power Button
Start
LED
Microcontroller
S1
B3SL-1002P
R10
10k
Reset
J10
ICSP2
J9
FTDI
GND
CTS
VCC
RXD
TXD
RTS
C11
0.1uF
Reset
Programming connectors
Brains


+5V
R6 10k
R5 10k
R91
R32 10k
SCL
SDA
U6
SCL
SDA
A2
A1
A0
Reset
NC
INT
Vss
VDD
GP7
GP6
GP5
GP4
GP3
GP2
GP1
GP0
MCP23008
C31 0.1uF
GND_DIGITAL
J21
Q3
IN_1
IN_2
IN_3
IN_4
IN_5
IN_6
IN_7
IN_8
GND
OUT_1
OUT_2
OUT_3
OUT_4
OUT_5
OUT_6
OUT_7
OUT_8
COM_D
ULN2803
+12V
Hold In 3
Pull In 3
Pull In 2
Hold In 2
Inrush 2
Pull In 1
Hold In 1
Inrush 1
R8 220R
R4 220R
K4
K5
K2
K3
Mains
Inrush 1
Power 1
Power 2
Inrush 2
F3
F2
R7
SL22-20005
R1
J6
J7
COMMON
R2 220R
K1
F4
J3
Tube
Relays