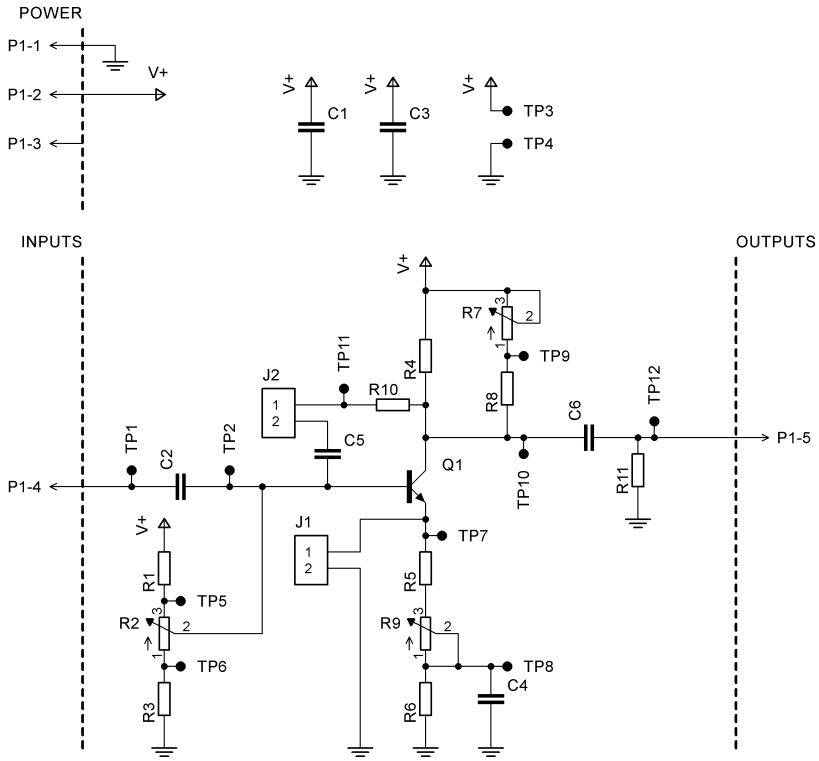
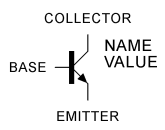
Common Emitter (Source) Amplifier

NOTES:

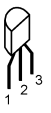


PART: NPN BIPOLAR JUNCTION TRANSISTOR	
FOOTPRINT: TO92	EXAMPLE PART: 2N3904

SCHEMATIC SYMBOL

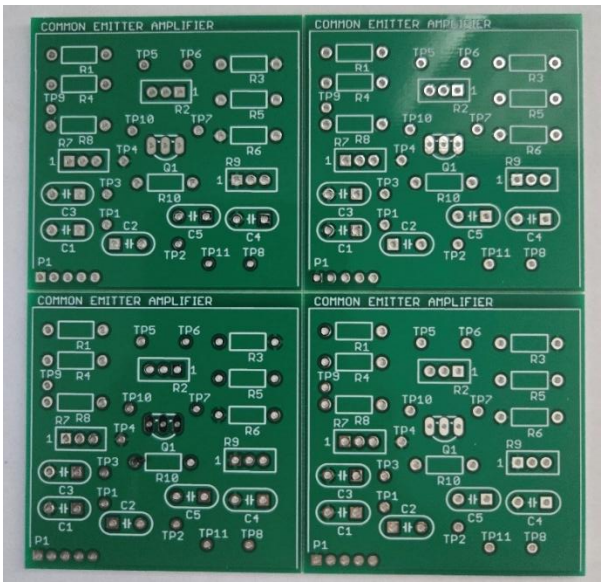


PINOUT

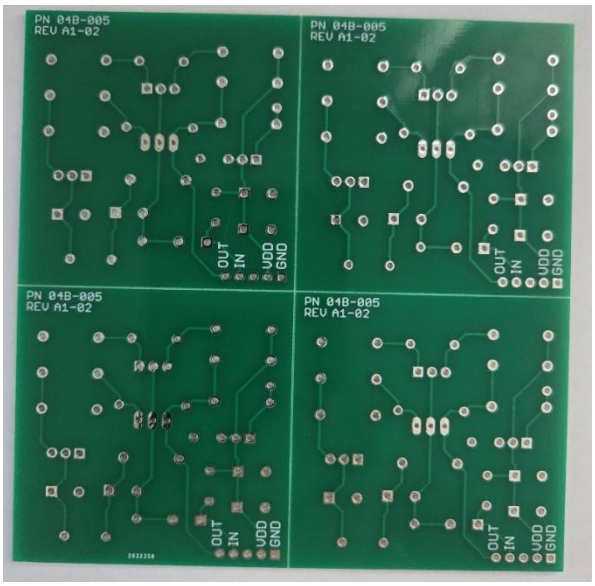


PIN	DESCRIPTION
1	EMITTER
2	BASE
3	COLLECTOR

TITLE		
COMMON EMITTER AMPLIFIER		
SIZE A	DWG NO 04B-005	REV A1-04
SAVED 6/20/2025 7:36:55 AM		SHEET 1/2



Front Side



Back Side

miniPCB Part Number

PART NO	TITLE	PIECES PER PANEL
04B-005	Common Emitter Amplifier	4

miniPCB Revision History

REV	DESCRIPTION	DATE
A1-01	Initial Release	03DEC2024
A1-02	Updated PCB outline and removed logo.	30APR2025
A1-03	Added AC coupling capacitor, C6. Added load resistor, R11. Added TP12.	19JUN2025
A1-04	Moved R9 in circuit.	20JUN2025

Pinout

REF DES	SIGNAL DESCRIPTION
P1-1	GND, Power input return
P1-2	V+, Power input source
P1-3	No Connection
P1-4	Signal Input, To Amplifier
P1-5	Signal Output, From Amplifier

Test Points

REF DES	SIGNAL DESCRIPTION
TP1	Input signal, DC coupled
TP2	Transistor base (gate)
TP3	V+, Power input source
TP4	GND, Power input return
TP5	R2 pin 3
TP6	R2 pin 1
TP7	Transistor emitter (source)
TP8	Emitter bypass capacitor
TP9	R7 pin 1
TP10	Transistor collector (drain)
TP11	AC feedback loop node
TP12	Output signal, DC coupled

Circuit Description

This miniPCB implements a single-stage common emitter amplifier designed around a discrete NPN bipolar junction transistor (Q1), with optional substitution for an N-channel JFET or MOSFET. The amplifier may be used to demonstrate voltage gain, phase inversion, and the effects of feedback and biasing techniques.

Power Supply Conditioning

Capacitors C1 and C3 serve as power rail decoupling and filtering elements, suppressing high-frequency noise and stabilizing the DC supply voltage. Test points TP3 (V+) and TP4 (GND) are provided for measuring supply and ground reference levels.

Input Coupling and Biasing

The AC input signal is capacitively coupled to the amplifier via C2, which blocks DC offset from the signal source, ensuring proper biasing of the transistor base.

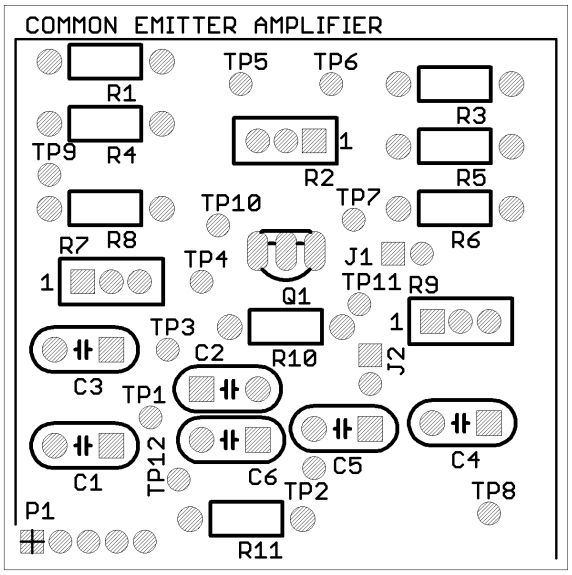


Figure 1 - Single Board, Component Outlines

Test points TP1 and TP2 allow voltage measurements across this input coupling capacitor.

Biasing of the transistor base is achieved through a resistor divider network consisting of R1, R2, and R3, with R2 implemented as a multiturn potentiometer for fine adjustment of the base voltage and operating point. This sets the quiescent collector current and ensures linear amplifier operation in the active region.

Test points TP5 and TP6 monitor voltages at key nodes within this bias network.

Feedback Network

A resistive-capacitive feedback loop composed of R10 and C5 connects the transistor's collector to its base. This provides frequency-dependent negative feedback that stabilizes gain, reduces distortion, and improves bandwidth. TP11 allows direct access to a point within this feedback path for analysis. Jumper J2 allows the feedback network to be removed from the circuit.

Collector Network and Output

The collector load consists of R4, R7, and R8, with R7 as a multiturn potentiometer to adjust gain or output bias. These resistors determine the voltage drop across the collector and directly affect the voltage gain. TP9 and TP10 are used to probe the collector and output signal path.

Emitter Network and Stability

The emitter is grounded through a multi-resistor network consisting of R5, R6, and R9 (with R9 being adjustable). These resistors set the emitter current and provide thermal stability through negative feedback.

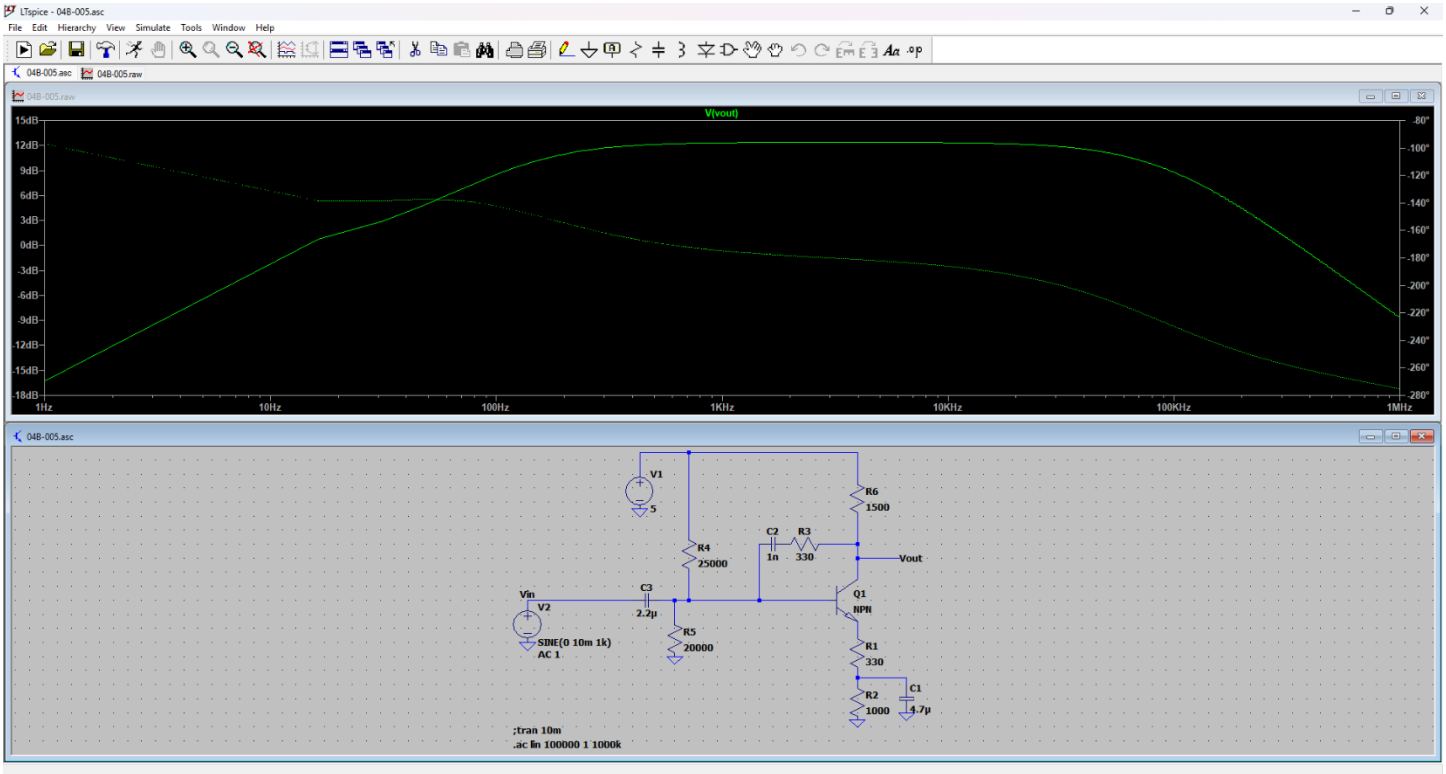
The AC bypass capacitor C4 is placed in parallel with part of the emitter resistance to increase gain at higher frequencies by reducing AC degeneration. TP7 and TP8 enable measurement of the emitter voltage and overall emitter network behavior. Jumper J1 allows the emitter network to be removed from the circuit.

Transistor Configuration

Q1 serves as the active amplifying device in the common emitter configuration. In the provided schematic, Q1 is a general-purpose NPN BJT. However, the board layout and biasing are designed to accommodate equivalent N-channel field-effect transistors (JFETs or MOSFETs) for experimentation with different semiconductor technologies.

Simulation in LTspice

LTspice was used to verify that selected component values produced reasonable amplifier behavior before assembling physical boards. The simulation helped confirm that the circuit was biased correctly, the signal was amplified, and the overall configuration functioned as expected with a voltage gain slightly greater than 4. While the analysis wasn't exhaustive, the simulation served as a practical check to ensure the design was sound and worth building.



Example Parts List

REF DES	PART TYPE	VALUE / DESCRIPTION
C1	CAPACITOR	4.7uF
C2	CAPACITOR	2.2uF
C3	CAPACITOR	0.1uF
C4	CAPACITOR	4.7uF
C5	CAPACITOR	1nF
C6	CAPACITOR	2.2uF
J1	JUMPER	0.1” HEADER PINS WITH JUMPER
J2	JUMPER	0.1” HEADER PINS WITH JUMPER
R1	RESISTOR	10kΩ
R2	RESISTOR	25kΩ
R3	RESISTOR	10kΩ
R4	RESISTOR	3.3kΩ
R5	RESISTOR	330Ω
R6	RESISTOR	1.5kΩ
R7	RESISTOR	2kΩ
R8	RESISTOR	3.3kΩ
R9	RESISTOR	2kΩ
R10	RESISTOR	330Ω
R11	RESISTOR	10kΩ
Q1	TRANSISTOR	2N3904
TP1-TP12	TEST POINT	KEYSTONE ELECTRONICS SERIES 5000
P1	HEADER PINS	5POS, 2.54mm PITCH, RA

Parts List Form

REF DES	PART TYPE	VALUE / DESCRIPTION
C1	CAPACITOR	
C2	CAPACITOR	
C3	CAPACITOR	
C4	CAPACITOR	
C5	CAPACITOR	
C6	CAPACITOR	
J1	JUMPER	0.1” HEADER PINS WITH JUMPER
J2	JUMPER	0.1” HEADER PINS WITH JUMPER
R1	RESISTOR	
R2	RESISTOR	
R3	RESISTOR	
R4	RESISTOR	
R5	RESISTOR	
R6	RESISTOR	
R7	RESISTOR	
R8	RESISTOR	
R9	RESISTOR	
R10	RESISTOR	
R11	RESISTOR	
Q1	TRANSISTOR	
TP1-TP12	TEST POINT	KEYSTONE ELECTRONICS SERIES 5000
P1	HEADER PINS	5POS, 2.54mm PITCH, RA

Build

NEED TO ADD

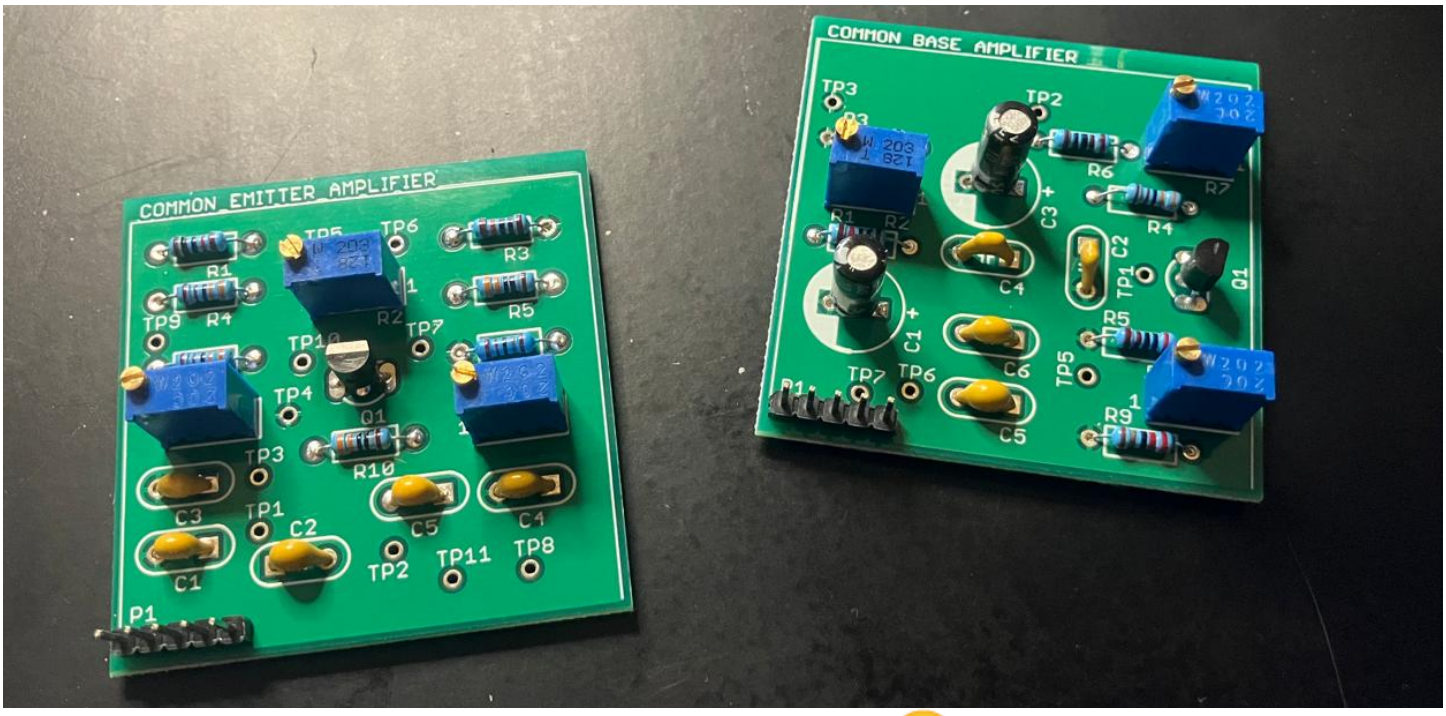
Testing

NEED TO ADD

Industry Feedback

University of Denver, Goncalo, 15JUN2025

The feedback provided by Goncalo directly affected changes made to Rev A1-03.

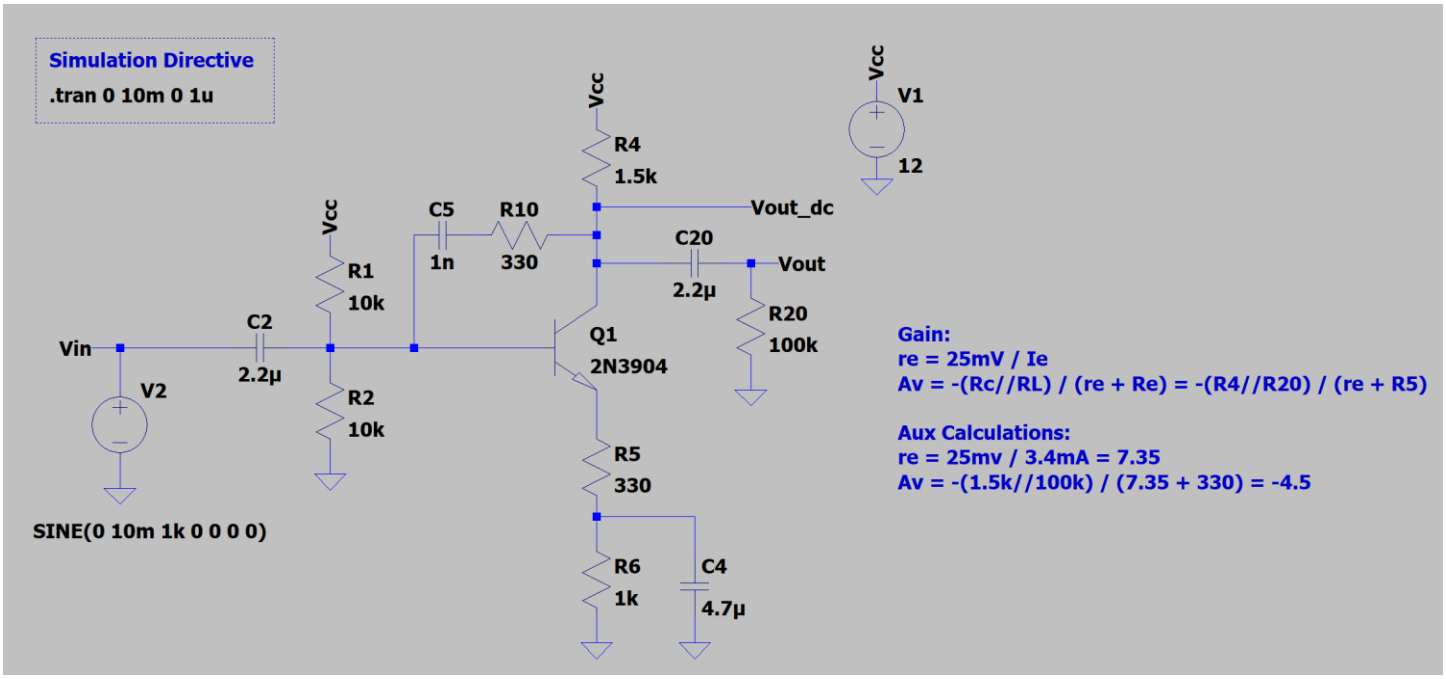


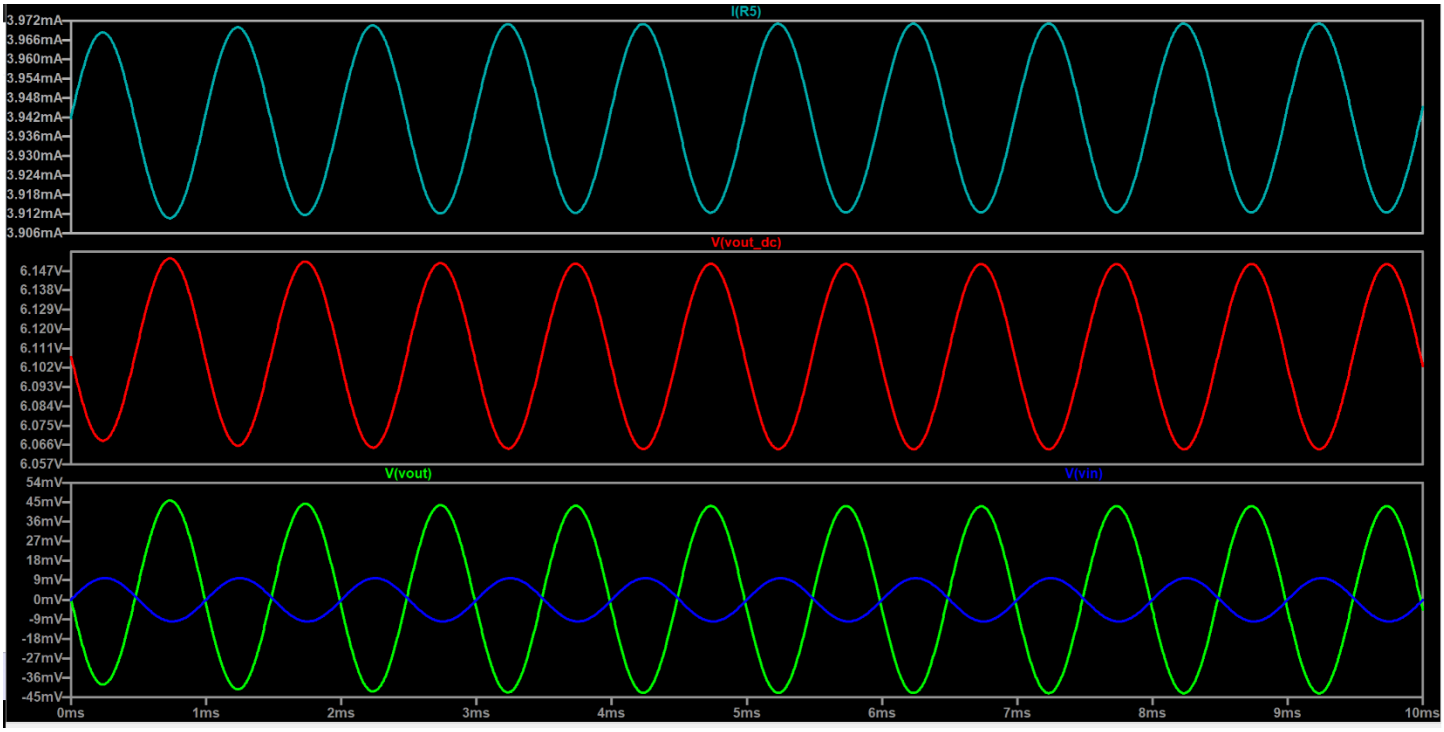
Thank you. Easy board to solder and you did a good job with the silkscreen 🙂

Updates on simulation and lab bench results

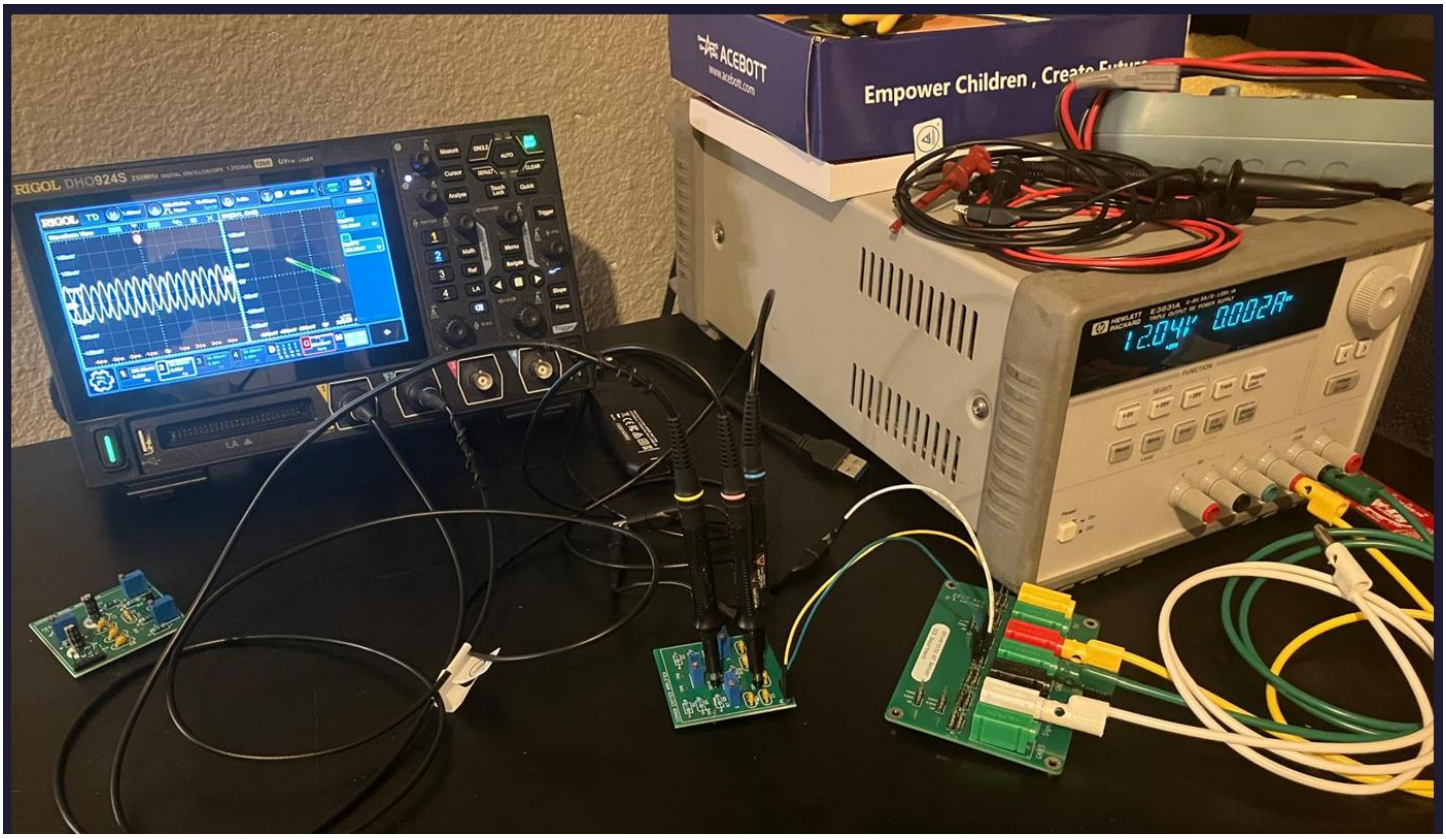
I will start with the LTSpice Simulations

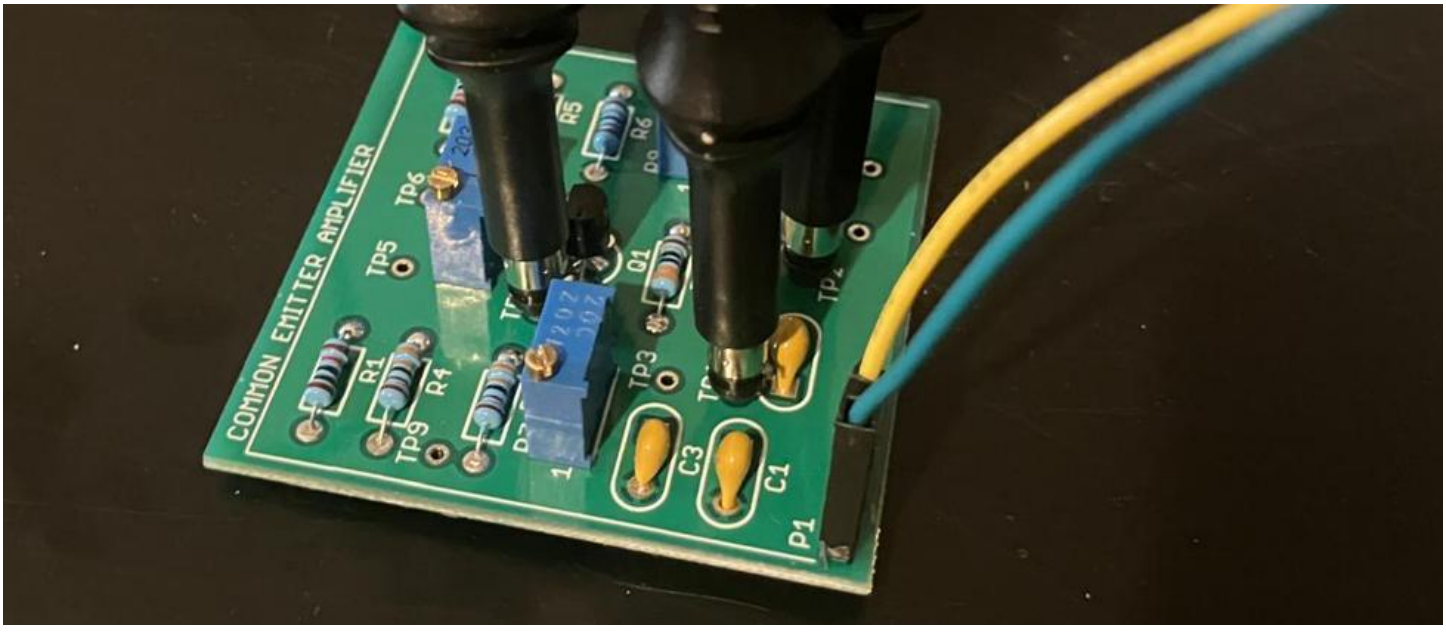
- *I re-did the LTSpice simulations and updated the values according to the values used in the lab bench.*
- *Changed Q1 to the 2N3904*
- *Added a couple of comments on the simulation mainly because that can help people understand where the gain is coming from*
- *Comments on the LTSpice can be refined to explain the importance of C4 etc. Maybe that explanation can be included in your LTSpice simulation section? I don't know how much extensive you want to be in terms of theory on the document. At the same time can be cool to not say much so students can explore?*


Simulation Directive
.tran 0 10m 0 1u
Vcc
V1
12
R4
1.5k
Vcc
C5
1n
R10
330
Vout_dc
C20
2.2µ
Vout
R1
10k
R20
100k
C2
2.2µ
Vin
Q1
2N3904
V2
R2
10k
R5
330
R6
1k
C4
4.7µ
SINE(0 10m 1k 0 0 0 0)
Gain:
re = 25mV / Ie
Av = -(Rc//RL) / (re + Re) = -(R4//R20) / (re + R5)
Aux Calculations:
re = 25mv / 3.4mA = 7.35
Av = -(1.5k//100k) / (7.35 + 330) = -4.5


I(R5)
3.972mA
3.966mA
3.960mA
3.954mA
3.948mA
3.942mA
3.936mA
3.930mA
3.924mA
3.918mA
3.912mA
3.906mA
V(vout_dc)
6.147V
6.138V
6.129V
6.120V
6.111V
6.102V
6.093V
6.084V
6.075V
6.066V
6.057V
V(vout)
V(vin)
54mV
45mV
36mV
27mV
18mV
9mV
0mV
-9mV
-18mV
-27mV
-36mV
-45mV
0ms
1ms
2ms
3ms
4ms
5ms
6ms
7ms
8ms
9ms
10ms

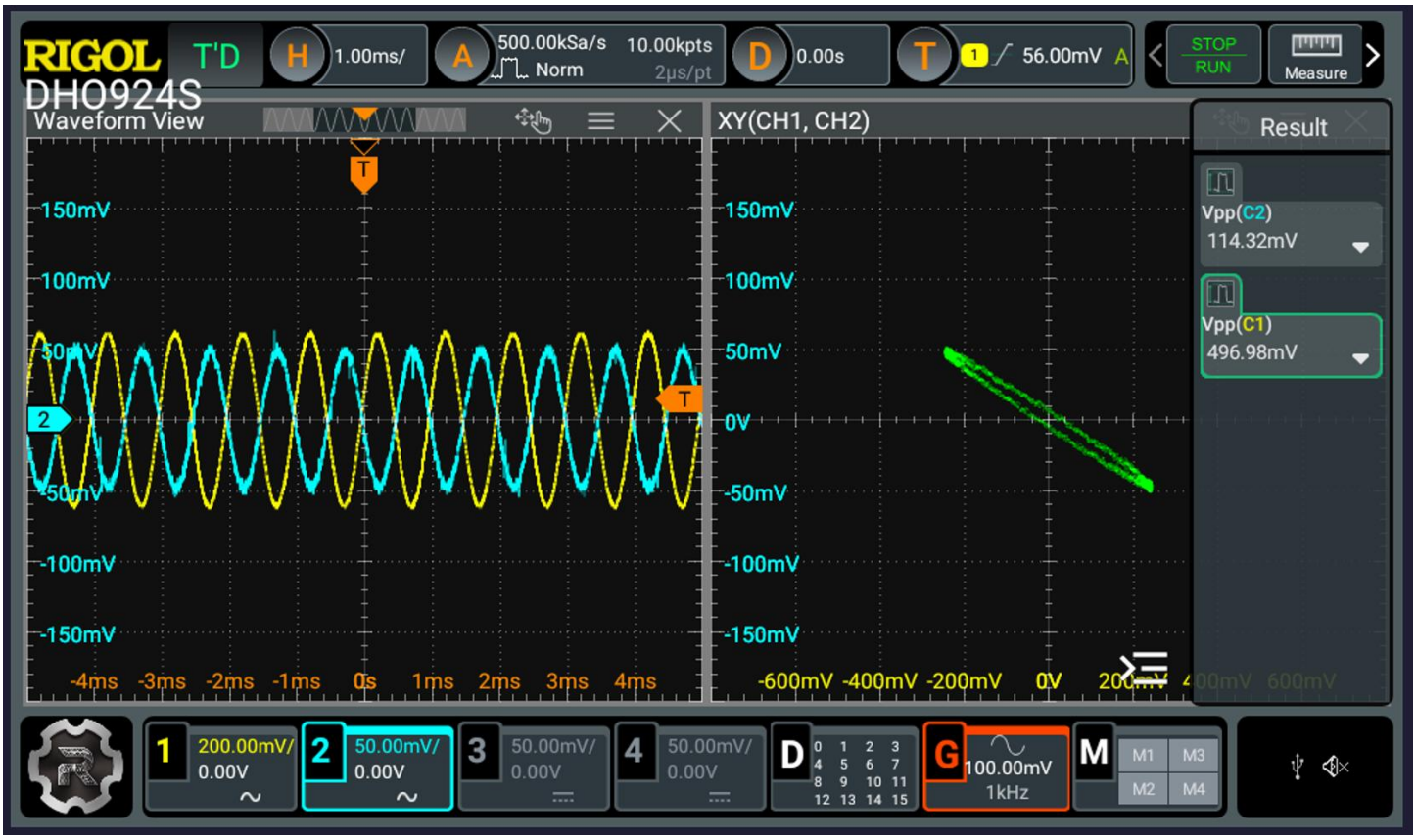
Lab bench results:

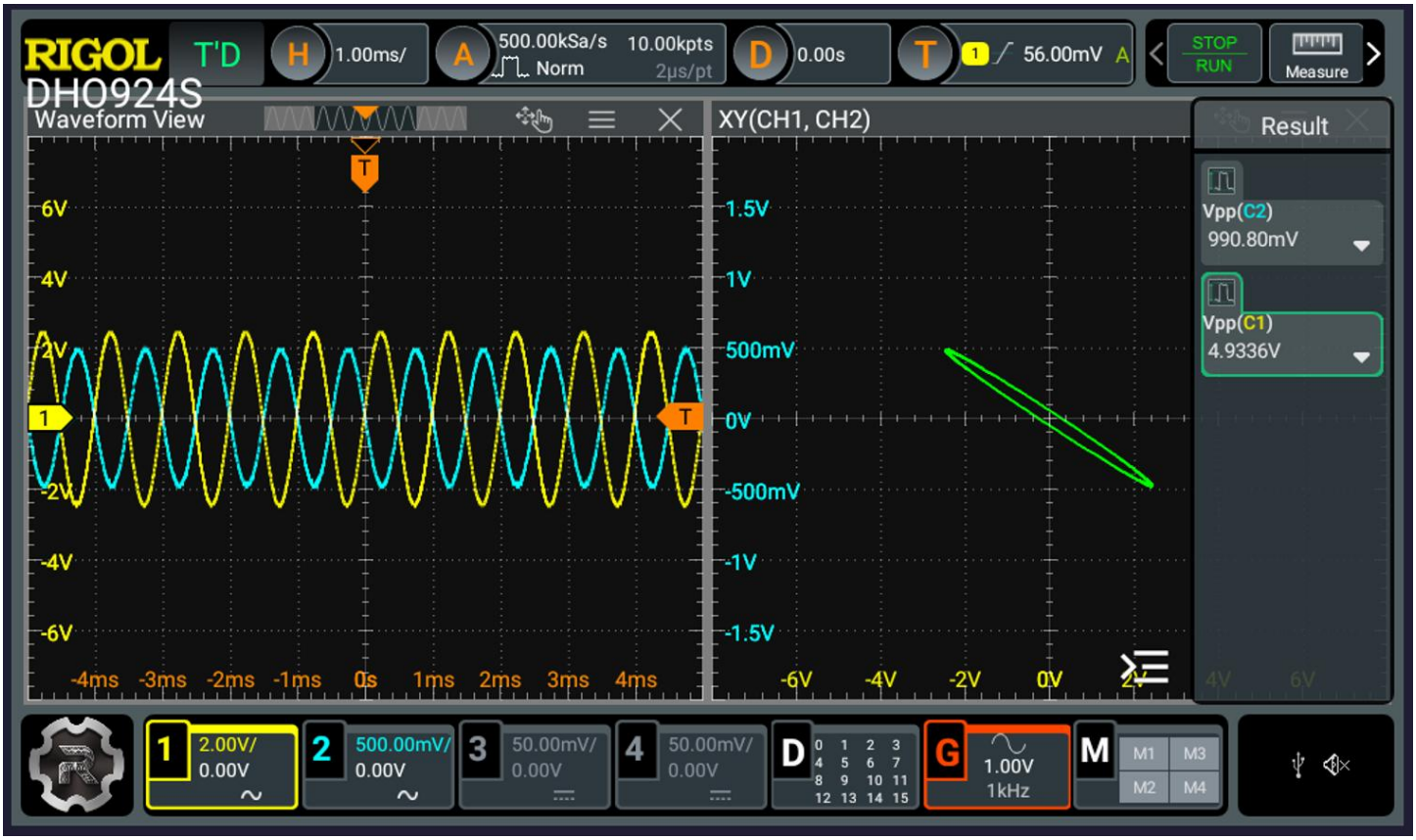




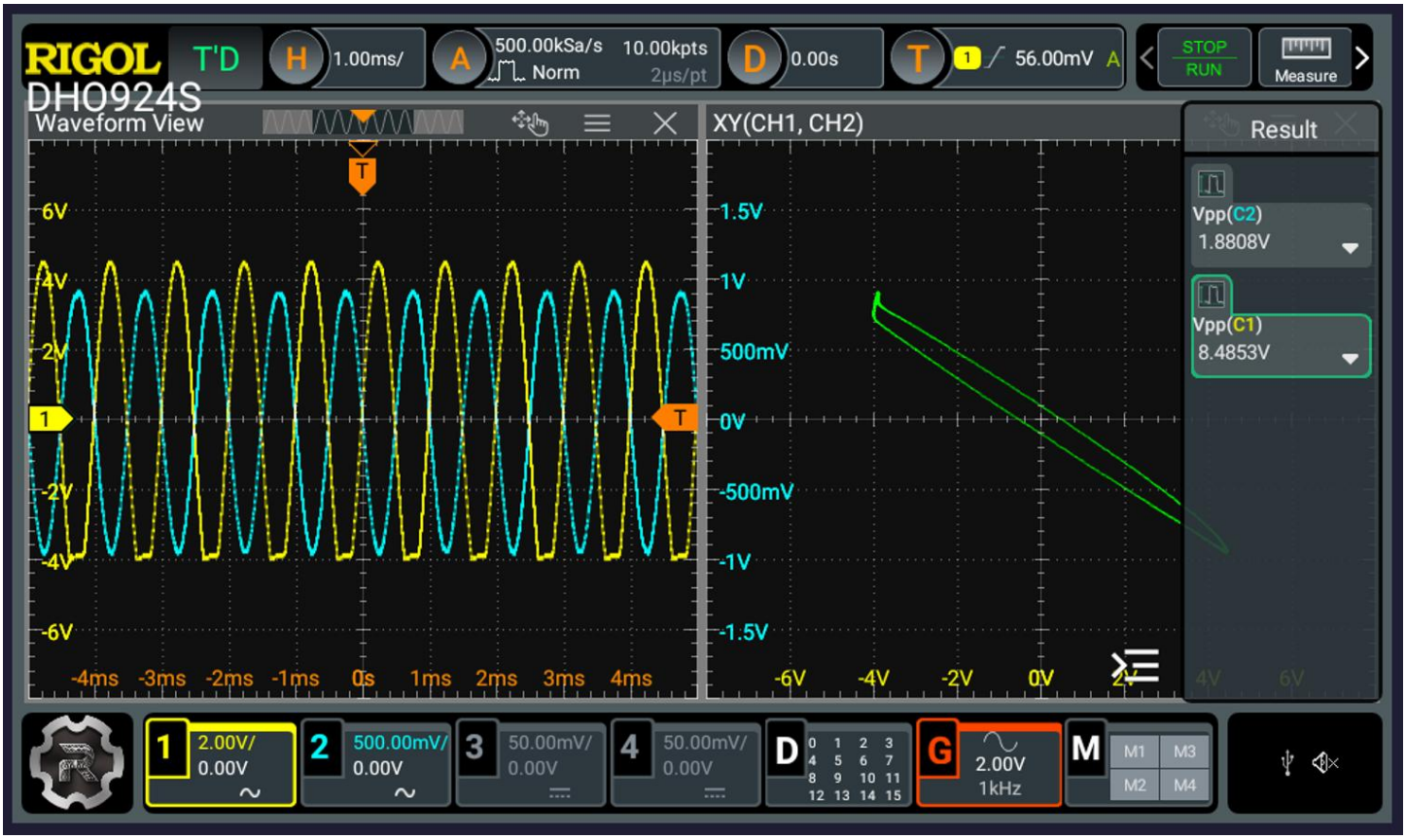
- *Overall, all went well and as expected.*
- *It is cool to see the bias changing by moving R2 trimmer*
- *Maybe R7 could be a bigger value so we can see more gain increase?*

I tested the circuit with a 100mV, 1V and 2V input signal (blue waveform) and observed the output signal (yellow waveform). I also tested the linearity of the system by observing the XY plot. The results that you see below are with the oscilloscope probes AC coupled.





With a 2V input and a gain of around 4.5 you can see saturation happening. Pretty cool 🙂



A couple of things that I would include on the PCB:

- *A jumper between R5 and ground. It would be nice to have the ability to bypass C4.*
- *It would be cool to have C4 being variable to understand the importance of selecting that value. Maybe instead of variable you could have a pin header and swap different capacitors in that place? Again, this all depends on how you want this kit to be used.*
- *I would also include a decoupling capacitor after TP10 and a load resistor. That load resistor is important for the output gain (as shown in the LTSpice simulation). I would add a TP after the load.*

I hope this helps for now and let me know your thoughts.

Best,

Goncalo

References

- https://www.minipcb.com/04B/04B-005.html
- https://www.youtube.com/@minipcb

Revision History

REV	DESCRIPTION	DATE
A	Initial Release	