

# Amplifier Design Record

## Class A Amplifier Design

**Print these sheets and use them in conjunction with the notes on the “Class A Amplifier Design” web pages in “Amplifiers Modules 2.1 to 2.4” at :**

<http://www.learnabout-electronics.org/Amplifiers/amplifiers20.php>

In this exercise you will learn to design, build and test a class A common emitter amplifier

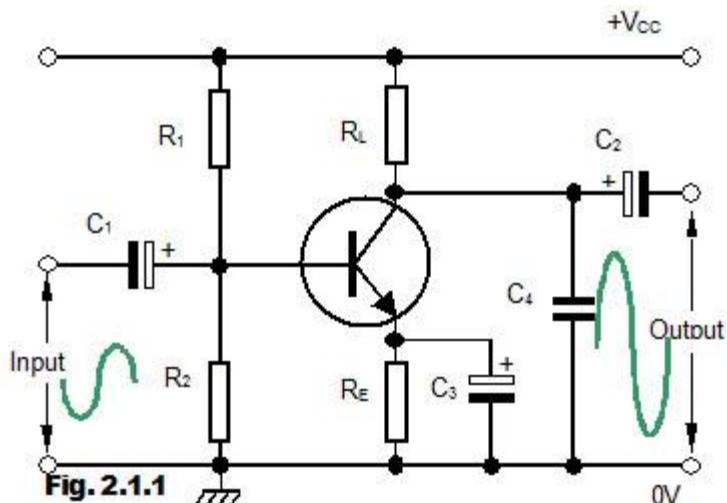
The exercise does not need any complex mathematical analysis. It uses only some of Ohm's law and reactance calculations. It also requires a basic understanding of components and measurement techniques using a multi-meter, function generator and oscilloscope.

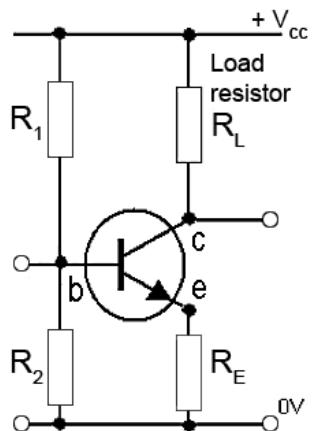
**Part 1** involves designing, building and testing the DC condition of the amplifier on breadboard.

**Part 2**, covers the calculation and fitting of the necessary AC components

In Part 3 the amplifier is tested under signal conditions and the design is further refined in Part 4

A great way to learn about electronics!





## Part 1. Designing the DC conditions.

To be used with Amplifier Module 2.1

**Fig. 2.1.2 Amplifier DC components**

1. DC supply voltage $V_{cc}$	$V_{cc} = \underline{\hspace{2cm}} V$
2. Choose a general purpose NPN small signal transistor and download a datasheet.	Transistor type _____
3. Quiescent Collector Current $I_q$	Quiescent Collector Current $I_q = \underline{\hspace{2cm}} mA$
4. Value of the load resistor $R_L$ using half the supply voltage $V_{cc}$ divided by $I_c$ $R_L = \frac{V_{cc} \times 0.5}{I_c}$	$R_L = \underline{\hspace{2cm}} \Omega$ Nearest preferred value = $\underline{\hspace{2cm}} \Omega$
5. Value of $V_E$ and $R_E$ $V_E = 10\% \text{ to } 15\% \text{ of } V_{cc}$ $R_E$ can be calculated by: $\frac{V_E}{I_E}$	$V_E = \underline{\hspace{2cm}} V$ $R_E = \underline{\hspace{2cm}} \Omega$ Nearest preferred value = $\underline{\hspace{2cm}} \Omega$
6. Estimated value of base current $I_B$ <ol style="list-style-type: none"> <li>Estimated current gain <math>h_{fe}</math> (from data sheet)</li> <li>Base current <math>I_B = I_C / h_{fe}</math></li> </ol>	$h_{fe} = \underline{\hspace{2cm}}$ $I_B = \underline{\hspace{2cm}} \mu A$
7. Value of $V_B$ $V_B$ should be about 0.7V (700mV) higher than $V_E$	$V_B = \underline{\hspace{2cm}} V$
8. DC bias network current. The current flowing through $R_1$ and $R_2$ will be: $I_B \times 10$	Bias Network Current $I_{R1R2} \underline{\hspace{2cm}} mA$
9. The resistance for $R_1$ $\frac{V_{CC} - V_B}{I_B \times 10}$	$R_1 = \underline{\hspace{2cm}} \Omega$ Nearest preferred value = $\underline{\hspace{2cm}} \Omega$
10. Calculate The resistance for $R_2$ The base voltage $V_B$ , divided by the current through $R_1$ and $R_2$ $\frac{V_B}{I_B \times 10}$	$R_2 = \underline{\hspace{2cm}} \Omega$ Nearest preferred value = $\underline{\hspace{2cm}} \Omega$
11. Start building with the DC Components That completes the calculation of the DC conditions for the amplifier. It can be built (DON'T FIT ANY CAPACITORS YET) and tested to check that the correct voltages are present on each of the collector, base and emitter of the transistor.	
12. Measure the collector, base and emitter voltages and write down their measured values. $V_C$ approx $V_{CC} \times 0.5$ $V_B$ approx 0.7V higher than $V_E$ $V_E$ approx 10% to 15% of $V_{CC}$	$V_C = \underline{\hspace{2cm}} V$ $V_B = \underline{\hspace{2cm}} V$ $V_E = \underline{\hspace{2cm}} V$

## Part 2. Adding the AC Components.

To be used with Amplifier  
Module 2.2

Adding the three electrolytic capacitors to the design will:

- Isolate the amplifier from any DC voltages due to circuits connected to the amplifier's input or output terminals.
- Considerably increase and control the voltage gain of the amplifier.

1.	<b>Choose an initial value for C<sub>1</sub> and C<sub>2</sub></b>	C <sub>1</sub> and C <sub>2</sub> = _____ μF
2.	<b>Choosing a value for C<sub>3</sub></b>  $X_C = \frac{1}{2\pi fC} \therefore C = \frac{1}{2\pi fX_C}$	Preferred value of R <sub>E</sub> = _____ Ω (From Part 1, step 5)  Value of C <sub>3</sub> = _____ μF Xc at 20Hz _____ Ω

**WARNING:** Be extra careful when connecting electrolytic capacitors to ensure they are connected with the correct polarity, see Fig. 2.2.3 showing negative lead marking on a capacitor, but note that the convention in circuit schematic diagrams (Fig. 2.2.1) is to mark the **positive** plate of an electrolytic capacitor with a + symbol. Fig. 2.2.3 also shows the safe working voltage of the capacitor, which must be high enough to withstand any likely voltage they will be subject to in the circuit.

Connecting electrolytic capacitors the wrong way round, or exceeding their working voltage can cause them to EXPLODE!



**Fig 2.2.3**

After switching off the power to the circuit, capacitors C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> can now be added to the circuit on the 'Bread board' for testing.

(Carry out the initial checks in Part 3 before re-connecting the power)

## Part 3. Testing the amplifier under signal conditions.

To be used with Amplifier  
Module 2.3

1.	<b>Initial check.</b> <i>Visually double check the circuit and re-check the transistor voltages</i>	$V_C = \underline{\hspace{2cm}} V$ $V_B = \underline{\hspace{2cm}} V$ $V_E = \underline{\hspace{2cm}} V$
2.	<b>Gain (Voltage Amplification <math>A_v</math>).</b> <i>Amplification (<math>A_v</math>) is calculated by:</i> $\frac{V_{pp\text{ Output}}}{V_{pp\text{ Input}}}$ <i>This gives the ratio of output to input so does not have any units.</i>	<b>Voltage Amplification</b> $A_v = \underline{\hspace{2cm}}$
3.	<b>Input Impedance.</b> <i><math>Z_{in}</math> is the same value as the resistance of the variable resistor (after adjustment described on the amplifiers 15 page)</i>	$Z_{in} = \underline{\hspace{2cm}} \Omega$
4.	<b>Output Impedance <math>Z_{out}</math></b> <i><math>Z_{out}</math> is approximately equivalent to the resistance of <math>R_L</math>,</i>	$Z_{out} = \underline{\hspace{2cm}} \Omega$
5.	<b>Bandwidth.</b> <i>Checking the bandwidth of the amplifier requires the equipment set up shown in Fig. 2.3.3</i>  5a.) <i><math>V_{pp}</math> at 1kHz (generator amplitude adjusted so the oscilloscope shows a large, undistorted waveform that exactly fits an even number of horizontal graticule lines.</i>  5b.) <i>Calculate the -3dB level (This is <math>V_{pp}</math> at 1kHz measured in 5a multiplied by 0.707)</i>  5c.) <i>Without altering the generator amplitude, reduce the frequency of the input wave and record its <math>V_{pp}</math> as the frequency is reduced to where the amplitude of the output wave falls to 0.707 of that recorded in 5a. This is the low frequency -3dB limit of the bandwidth.</i>  5d.) <i>Increase the frequency past 1kHz until the output <math>V_{pp}</math> again falls to 0.707 of the 1kHz value. Record this frequency as the high frequency limit of the bandwidth.</i>	<b>Record the peak-to-peak value of the wave.</b> $V_{pp\text{ at }1\text{kHz}} = \underline{\hspace{2cm}} V$  <b>Calculate the -3dB level</b> $V_{pp\text{ at }1\text{kHz} \times 0.707} = \underline{\hspace{2cm}} V$  <b>Low frequency -3dB limit</b> $= \underline{\hspace{2cm}} \text{Hz}$  <b>High frequency -3dB limit</b> $= \underline{\hspace{2cm}} \text{kHz}$

It is quite probable that the amplifier bandwidth will not conform to a nice 20Hz to 20kHz specification, or that there may be variations in maximum gain over the frequency range. This is not the ideal situation for a good audio amplifier, so the design may need improving as described in part 4.

## Part 4. Improving The Design.

To be used with Amplifier Module 2.4

### 1. Introducing some negative feedback.

Since $A_V = R_L/R_E$ $R_E = R_L/50$	Value of $R_{NFB}$ (for a gain of 50) _____ $\Omega$
To keep $R_E + R_{NFB}$ value the same as original value of $R_E$	New value of $R_E$ = _____ $\Omega$
Re-measure gain at 1kHz(as in Part 3 measurement 2)	Gain at 1kHz with NFB = _____
Re measure $Z_{in}$	Input Impedance $Z_{in}$ (see Part 3) = _____ $\Omega$

### 2. Refining the Bandwidth.

The bandwidth of the amplifier needs to be as close to 20Hz to 20kHz as possible, this part of the design exercise will adjust the high and low frequency limits of the bandwidth. These are largely influenced by the values of C1 and C4 (C2 would also influence performance, mainly if an external load on the amplifier output were to be considered).

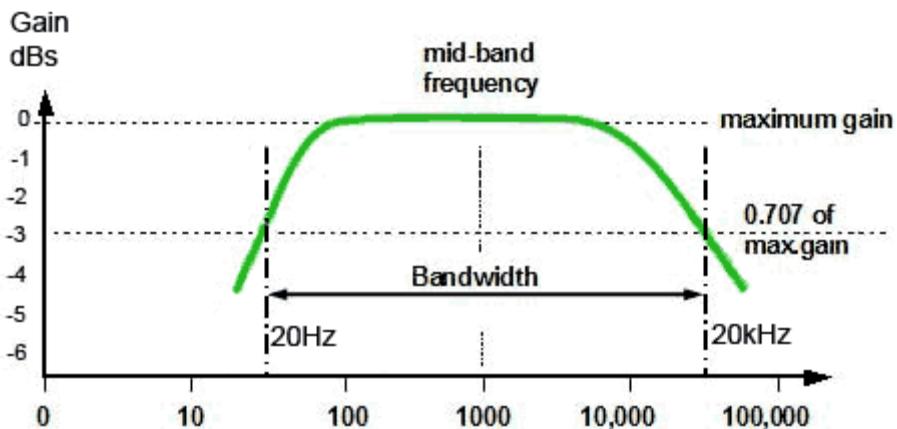


Fig. 2.4.2

Frequency (Hz) [logarithmic scale]

Calculate a value for C1. C1 and the input impedance ( $Z_{in}$ ) form a high pass filter. A suitable value for C1 can be found by re-arranging the standard formula for a filter corner frequency for 20Hz:	$C1 = \frac{1}{(2\pi f Z_{in})}$	Calculated Value of C1 for -3dB at 20Hz = _____ F Nearest preferred value for C1 = _____ F
Calculate a value for C4 C4 and the load resistor $R_L$ form a low pass filter. Re-arranging the standard formula for a filter corner frequency for 20kHz gives:	$C4 = \frac{1}{(2\pi f R_L)}$	Calculated Value of C4 for -3dB at 20kHz = _____ F Nearest preferred value for C4 = _____ F

### 3. Checking the Maximum undistorted output waveform

Maximum undistorted output waveform.	Output $V_{out}$ _____ $V_{pp}$
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