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 calcultion 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!

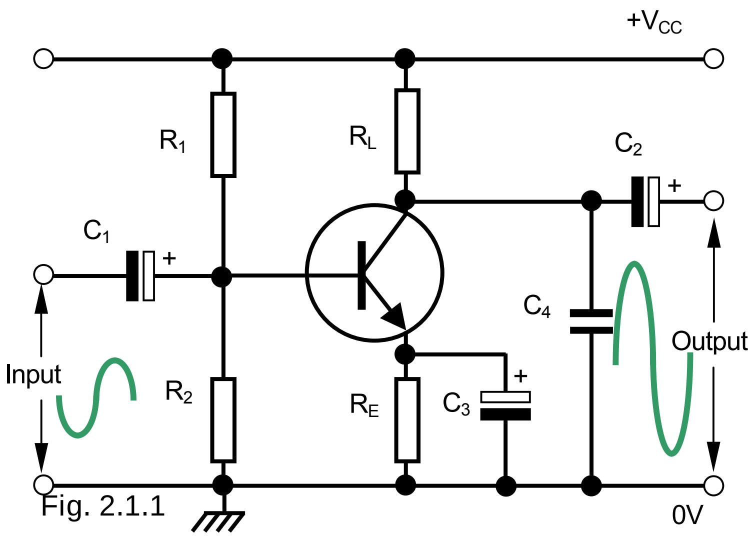
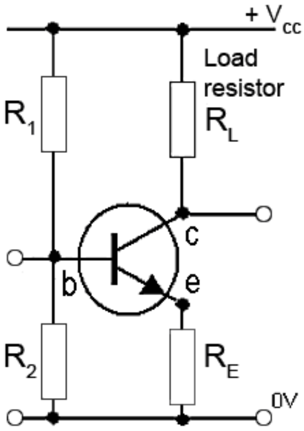


Fig. 2.1.1



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} = __________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 = _____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 = _________ Ω Nearest preferred value = _________ Ω
5.	**Value of V_E and R_E** *V_E=10% to 15% of V_{CC}* *R_E can be calculated by:* $\frac{V_E}{I_E}$	V_E =______V R_E =_______ Ω Nearest preferred value = ______ Ω
6.	**Estimated value of base current I_B** *a. Estimated current gain h_{fe} (from data sheet)* *b. Base current $I_B = I_C / h_{fe}$*	h_{fe} = _______ I_B = _______ μA
7.	**Value of V_B** *V_B should be about 0.7V (700mV) higher than V_E*	V_B =________V
8.	**DC bias network current.** *The current flowing through R_1 and R_2 will be:* I_B x 10	**Bias Network Current** I_{R1R2} ___________mA
9.	**The resistance for R_1** $\frac{V_{CC} - V_B}{I_B \times 10}$	R_1 =_________ Ω Nearest preferred value = _________ Ω
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* =__________ Ω Nearest preferred value = _________ Ω
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} x 0.5* *V_B approx 0,7V higher than V_E* *V_E approx 10% to 15% of V_{CC}*	*V_C = _________V* *V_B = _________V* *V_E = _________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.	***Choose an initial value for C_1 and C_2***	***C_1 and C_2 = ____________ μF***
2.	**Choosing a value for C3** $X_C = \frac{1}{2\pi fC} \therefore C = \frac{1}{2\pi fX_C}$	Preferred value of R_E =________ Ω *(From Part 1, step 5)* Value of C_3 = __________ μF Xc at 20Hz_______Ω

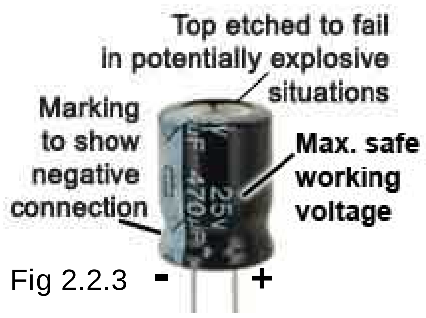


Fig 2.2.3

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!

After switching off the power to the circuit, capacitors C_1, C_2 and C_3 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.	**Initial check.** *Visually double check the circuit and re-check the transistor voltages*	V_C = _________V V_B = _________V V_E = _________V
2.	**Gain (Voltage Amplification A_v).** *Amplification (A_v) is calculated by:* $\frac{V_{pp}Output}{V_{pp}Input}$ *This gives the ratio of output to input so does not have any units.*	**Voltage Amplification** **A_v =** __________
3.	**Input Impedance.** *Z_{in}. is the same value as the resistance of the variable resistor (after adjustment described on the amplifiers15 page)*	Z_{in} =_________ Ω
4.	**Output Impedance Z_{out}** *Z_{out} is approximately equivalent to the resistance of R_L,*	Z_{out} = ___________ Ω
5.	**Bandwidth.** *Checking the bandwidth of the amplifier requires the equipment set up shown in Fig. 2.3.3*	
	5a.) Vpp at 1kHz (generator amplitude adjusted so the oscilloscope shows a large, undistorted waveform that exactly fits an even number of horizontal graticule lines. *5b.) Calculate the –3bB level (This is V_{PP} at 1kHz measured in 5a multiplied by 0.707)* *5c.) Without altering the generator amplitude, reduce the frequency of the input wave and record its V_{PP} 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.* *5d.) Increase the frequency past 1kHz until the output V_{PP} again falls to 0.707 of the 1kHz value.* *Record this frequency as the high frequency limit of the bandwidth.*	**Record the peak-to-peak value of the wave.** V_{PP} at 1kHz = _____________V **Calculate the –3dB level** V_{PP} at 1kHz x 0.707 = _____________V **Low frequency –3dB limit** = ____________Hz **High frequency –3dB limit** = ____________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) ____________Ω***
To keep R_E +R_{NFB} value the same as original value of R_E	***New value of R_E =____________Ω***
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) =________Ω***

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).

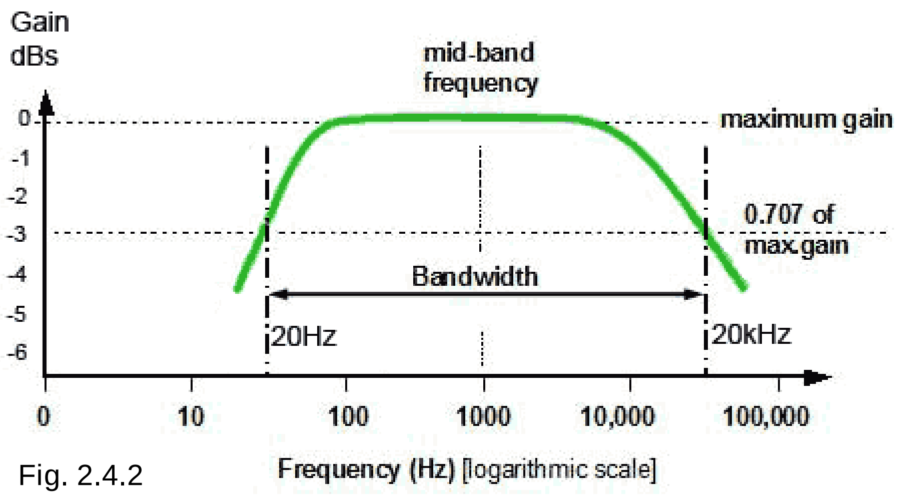


Fig. 2.4.2

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 C1 =_______ F***

3. Checking the Maximum undistorted output waveform

Maximum undistorted output waveform.	***Output V_{out}____________V_{pp}***

