

Power amplifier revision.

1). A student, who begins to learn to play the guitar, needs an amplifier so that she can practice. The output signal from the guitar has a maximum amplitude of 200mV and the guitar amplifier is to operate from a $\pm 12V$ supply.

(a) What is the maximum voltage gain needed by the amplifier?

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(2)

(b) If the amplifier drives a 4Ω loudspeaker, estimate the maximum power that the amplifier can deliver to the loudspeaker.

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(c) (i) Draw the circuit diagram of an inverting op-amp amplifier in the space below. Label the input and output.

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(ii) If the feedback resistor has a value of $1M\Omega$, calculate the value of the input resistor needed to give the required voltage gain.

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(2)

- (d) When the amplifier is constructed it is tested using a signal generator and an oscilloscope.
 - (i) In the space below, draw a diagram to show how you would arrange the test equipment and the amplifier to make the test measurements.

- (ii) Explain how you would measure the voltage gain of the amplifier. (3)

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- (iii) Explain how you would measure the bandwidth of the amplifier (2)

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- (iv) If the unity gain bandwidth product of the op-amp is 10^6 , estimate the bandwidth of the op-amp amplifier circuit (2)

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- (e) The op-amp amplifier performed as expected in the tests, but when the speaker was connected to the output of the op-amp very little power was delivered to the speaker. Explain why. (2)

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(2)

(f) To increase the power supplied to the speaker, it is suggested that MOSFET source followers are used to buffer the op-amp output to the speaker.

(i) Draw a labelled circuit symbol for a MOSFET.

(3)

(ii) Draw the circuit diagram for a MOSFET source follower.

(3)

(iii) State three properties of MOSFETs which make them ideally suited to this application.

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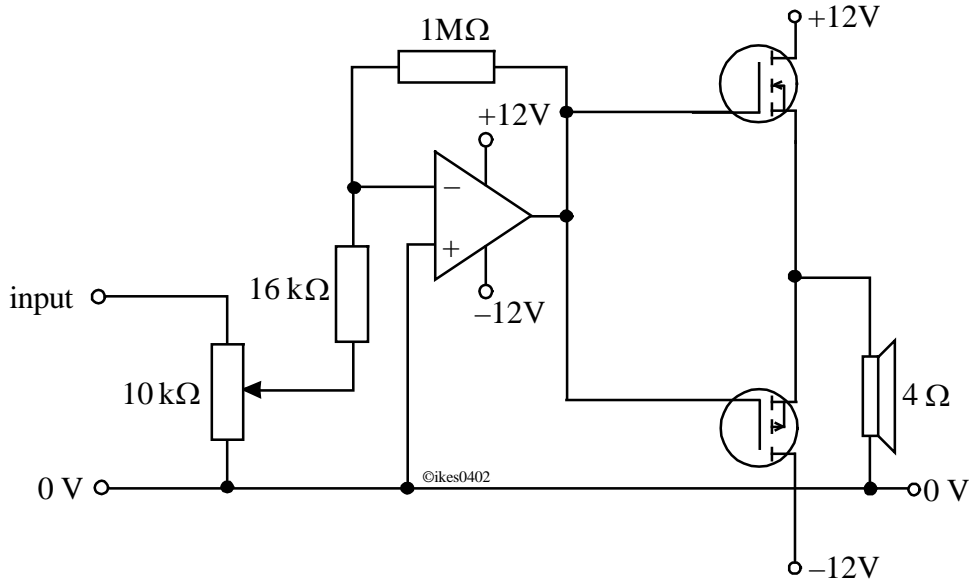
(3)

(iv) Explain why both a n-channel and a p-channel MOSFET is needed in this application.

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(3)

- (g) The op-amp circuit was changed to incorporate the MOSFET buffers as shown below.



- (i) What is the purpose of the 10kΩ potentiometer

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(1)

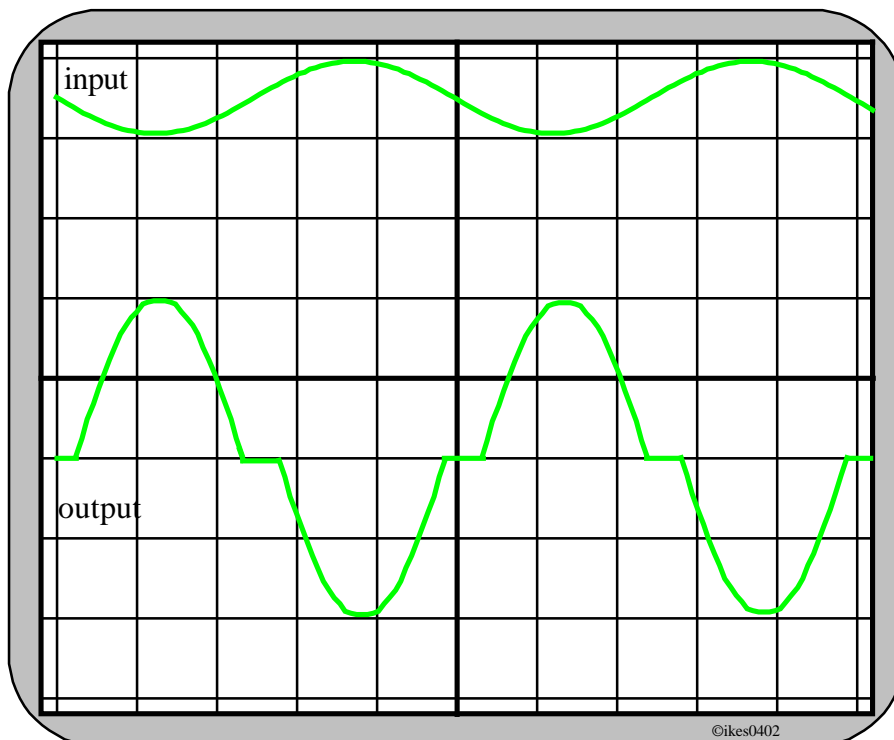
- (ii) Estimate the maximum overall voltage gain of the amplifier circuit above.

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(2)

- (h) With a sine wave input signal, the output voltage across the loudspeaker is distorted as shown in the oscilloscope trace below.



(i) The timebase of the oscilloscope is set to 0.2ms/div, what is the frequency of the input signal?

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(1)

(ii) The y-sensitivity of the input channel is set to 0.2V/div. What is the amplitude of the input signal?

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(1)

(iii) What is the name of the distortion observed in the output trace?

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(1)

(iv) Explain what causes the distortion observed in the output trace.

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(v) Explain **two** ways in which you would change the circuit of the amplifier to minimise this distortion.

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(3)

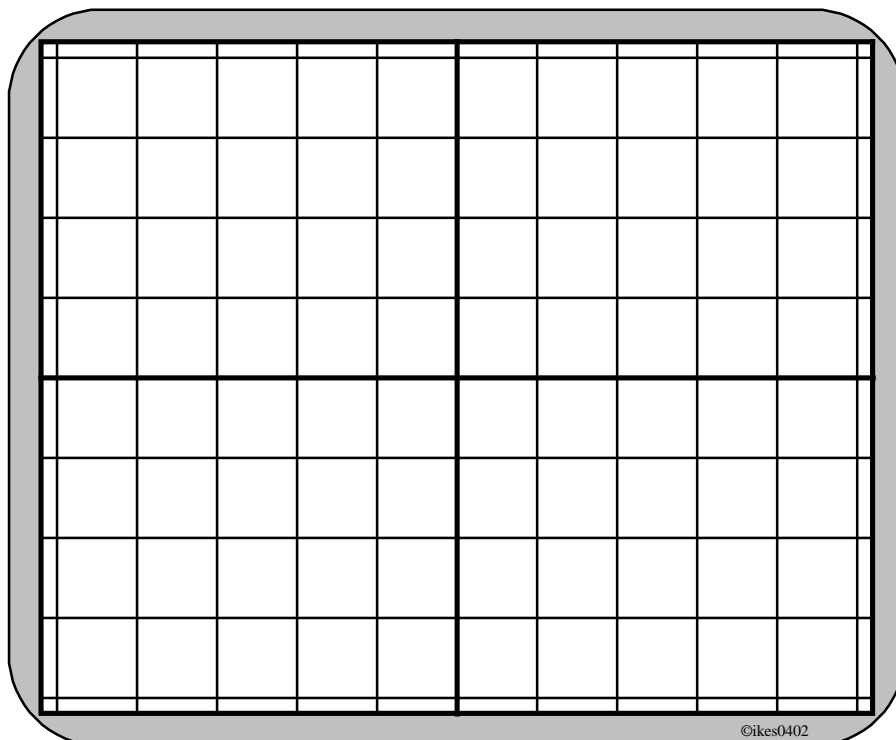
(vi) In the space below redraw the circuit diagram of the amplifier adding the modifications that you described in part (v).

(i) The modifications are carried out to the amplifier so that the distortion in part (h) is minimised. The amplifier is again tested and this time it is observed that with an input greater than 200mV amplitude another form of distortion occurs (4)

(i) Explain the origin of this new distortion.

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(ii) If the y-sensitivity of the output trace is 5V/div, sketch onto the oscilloscope diagram below, the output waveform for an input of 300mV (2)



(3)

(iii) Explain two ways in which this distortion can be minimised.

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(2)

(j) At maximum undistorted output, the amplifier delivers a peak voltage across the speaker of 10.5V for a sine wave input.

(i) Calculate the maximum power output of the amplifier to the speaker.

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(2)

(ii) Calculate the rms current through the speaker.

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(iii) Estimate the total power supplied to the amplifier under these conditions.

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(iv) Calculate the difference between the power supplied to the amplifier and the output power to the speaker.

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(1)

(v) What happens to this difference in power?

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(1)

(k) Under these conditions, the MOSFETs become very hot and have to be bolted to heatsinks.

(i) What is a heatsink?

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(1)

(ii) Describe three features of an efficient heatsink

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(3)