

**Learning Objectives:**

At the end of this topic you will be able to;

- ☑ draw a block diagram, and circuit diagram for a simple radio receiver, consisting of antenna, tuned circuit, detector/demodulator, and earphones;
- ☑ describe the function of each of these sub-systems;
- ☑ appreciate that a tuned circuit is a variable frequency band pass filter;
- ☑ design a tuned circuit to select a particular carrier frequency;
- ☑ select and use the equation  $C = \frac{1}{4\pi^2 f_o^2 L}$  to calculate the value of  $C$  to provide a given resonant frequency.
- ☑ use the frequency response curves of a loaded tuned circuit to explain poor selectivity.

### The Simple Radio Receiver

In section 4.3 we discussed a range of methods for linking an information signal with a high frequency carrier by means of a number of modulation techniques so that it can be transmitted. In this section we will explore some ways of retrieving the original signal so that it can be heard.

We will start with the simple radio receiver, which consists of five main functional blocks as shown below:



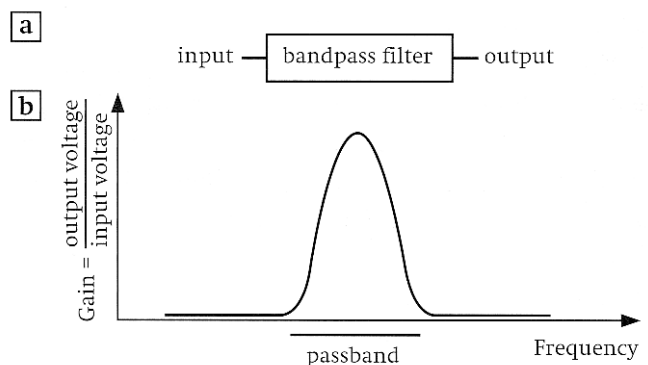
Every radio receiver requires an antenna (aerial) as the input, to convert the incoming radio waves into tiny alternating currents. Unlike the transmitting aerial which may only be transmitting one frequency from the radio station, the aerial will pick up all of the different radio broadcasts at different carrier frequencies within range. The actual current variation in the aerial will be a complex mixture of all these signals and so the first thing the receiver has to be designed to do is select one broadcast from among the many, and then extract its audio information.

#### The tuning circuit

A tuning circuit is essentially a band pass filter (Topic 4.2.3) designed to pick up carrier frequencies typically in the range 300kHz to 3MHz. The frequency range (i.e. the frequency band it passes) can be **altered** by means of a **variable capacitor**. The frequency response of the tuning circuit is the gain as a function of frequency, where

$$\text{gain} = \frac{\text{output voltage}}{\text{input voltage}}$$

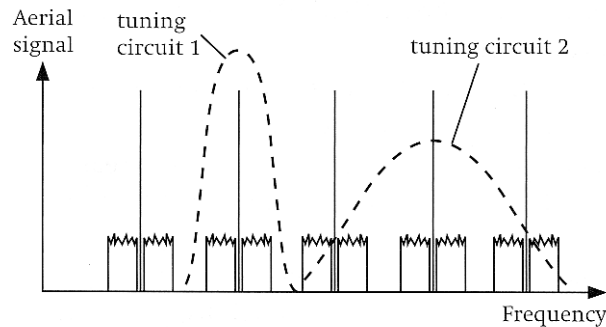
This is shown opposite (a) is the block diagram, (b) is the frequency response.



## Topic 4.4.1 - Simple AM Receiver



If this frequency response is now superimposed on the multi-carrier signal picked up by the aerial, then we have the graph shown below (where it is assumed that all transmissions are AM).



The frequency response curves for two types of tuning circuit are shown. Tuning circuit 1 has a pass band that has a high Q factor that just encompasses the carrier and sidebands, and so this tuner will be very selective, i.e. it will pick out just one station and reject the rest. Tuning circuit 2 has a much larger pass band and a lower Q-factor so is insufficiently selective; interference will occur between neighbouring transmissions.

The tuning circuit pass band is **centred** on the desired **carrier** frequency and the very small currents from this particular station are converted into very small voltages (typically  $\mu\text{V}$  or  $\text{mV}$ ). Thus a very small copy of the original AM signal will be produced.

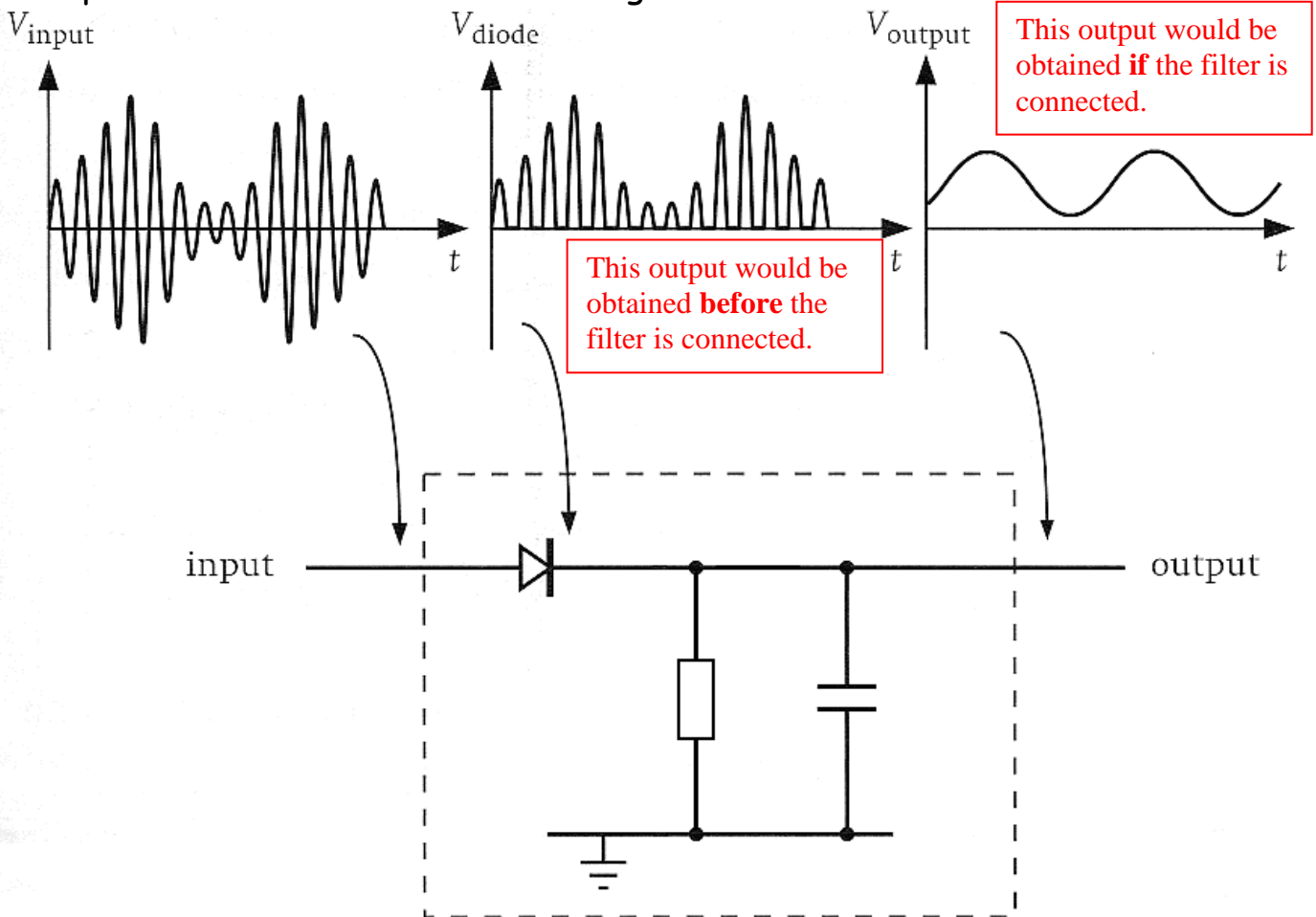
### The detector

The function of the detector is to extract (i.e. detect) the audio signal. It does this by first rectifying the AM carrier with a diode circuit, so that the average value of the AM signal is no longer zero. As the received signals are very small, special diodes with a very low turn-on voltage are used for this purpose. They are usually made with germanium and have a turn-on voltage of approximately 0.2V instead of the 0.7V for a silicon diode. Even so, unless the received signal is **well above 200mV** then this simple radio receiver will not be able to receive it as the signal will not be able to turn-on the diode in the detector.

The RF filter

The half wave rectified pulses are then smoothed with a low pass filter, so that the remaining carrier frequency is lost and the slowly changing envelope (i.e. the audio signal) is obtained as output.

The process of detection and filtering is shown below.

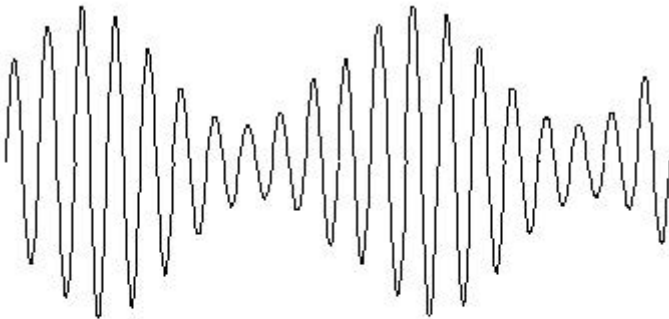


Note: a different type of low pass filter is used in the final stage as the type used in Topic 4.2.2. have a **series** resistor which would reduce the very small current in the radio receiver to an unacceptably low value. The good news however is that you don't have to know how this filter works just that it's break frequency is given by the same formula i.e.

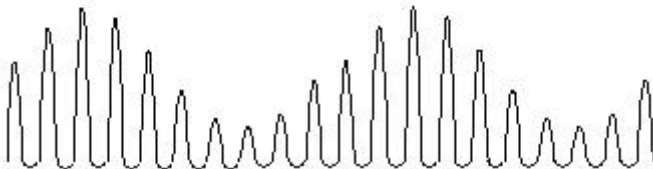
$$f_b = \frac{1}{2\pi RC} .$$

## Topic 4.4.1 - Simple AM Receiver

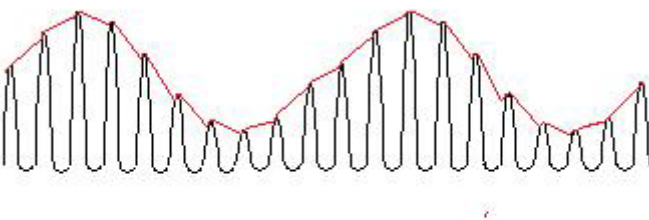
In practice the received signal would never be perfectly reproduced, the following diagrams show a more realistic output from the RF filter.



This is the amplitude modulated carrier.



This is the half wave rectified signal



The red line shows the attempt of the filter to reconstruct the original audio wave. The values of  $R$  and  $C$  used affect the quality of how smooth the peaks are joined.



The recovered audio frequency which is not perfectly smooth, and contains fluctuations.

The values of  $R$  and  $C$  need to be chosen carefully to produce:

- a break frequency just above the audio range of the information signal
- a time constant that is short compared with the period of the audio signal so the output follows the audio signal faithfully
- a time constant that is long compared with the period of the carrier so that  $C$  does not discharge appreciably and give a saw tooth effect superimposed on the audio signal
- a high impedance so that it does not draw a large current from the tuned circuit

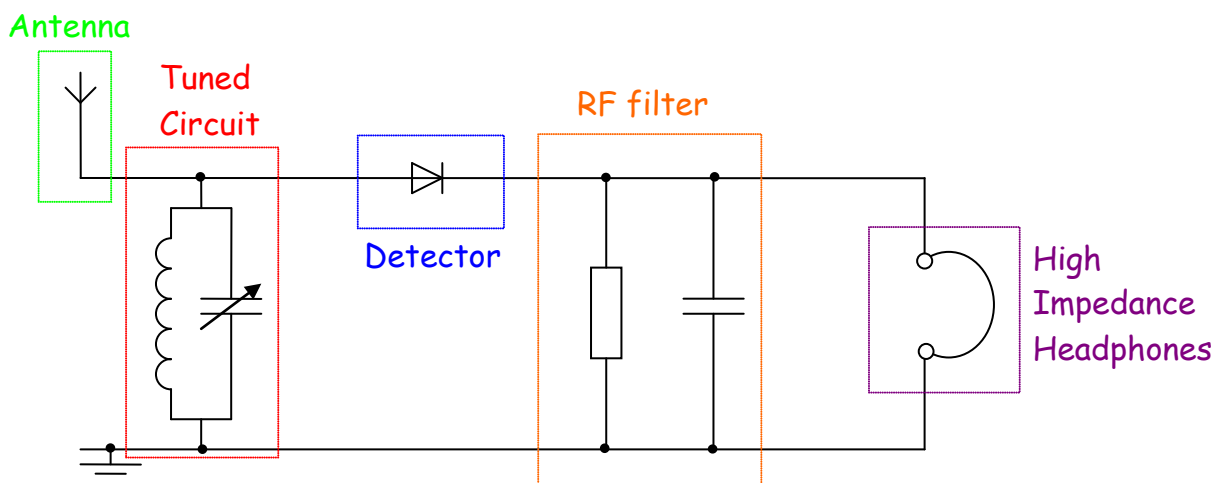
As a *rule of thumb* compromise,  $R$  is usually chosen to be greater than  $50\text{ k}\Omega$  along with a corresponding value of  $C$  in the range 20 to  $1000\text{pF}$ .

### The High Impedance Headphones

This is a transducer that converts the audio signal into small displacements of a diaphragm, so that the original audio information is recreated. The minor fluctuations in the audio signal tend to be ignored by most headphones. As this radio receives all of its power from the received radio signal it is unable to drive any output device other than very high impedance ( $\sim 1\text{M}\Omega$ ) headphones .

### Circuit diagram

The circuit diagram for a simple radio receiver is shown below.



**Note :** Sometimes the resistor in the RF filter is omitted from the circuit diagram because the internal impedance of the headphones is sufficient to work with the fixed capacitor to form the low pass filter. This circuit is powered only by the signal picked up by the antenna, no batteries or power supplies are needed. If you wanted to replace the headphones with a loudspeaker you would have to add an audio amplifier which would need a power source after the RF Filter.

## Topic 4.4.1 - Simple AM Receiver

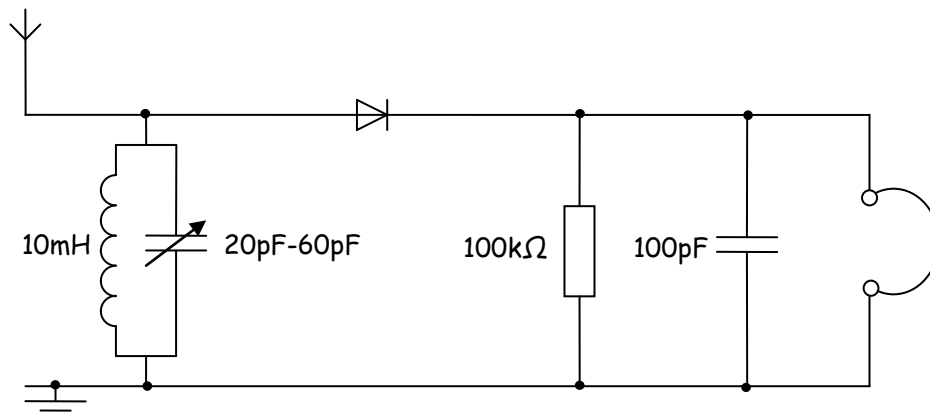


There are only a couple of calculations that can be performed on this circuit, which are as follows:

- i. using the tuned circuit components to calculate the range of frequencies that can be received by the radio, or given the frequency of a radio station, calculate the setting of the variable capacitor to ensure that this frequency is the one received.
- ii. Calculating suitable values for the RF filter circuit, so that it has a high impedance to the audio signal, and low impedance to the RF carrier.

We will now look at a couple of examples to see how these various calculations are performed. **However it is important to remember that all calculations will be based on a theoretical model, where loading effects will be ignored.**

1. The following circuit shows a simple radio receiver



- (a) Calculate the minimum and maximum frequency that the tuned circuit of this radio can respond to.
- (b) (i) Calculate the break frequency of the RF Filter.  
(ii) Comment on the suitability of the break frequency for this particular radio receiver.

Solution:

- (a) To calculate the resonant frequency of the tuned circuit for minimum and maximum values of the variable capacitor we must apply the formula  $f_o = \frac{1}{2\pi\sqrt{LC}}$  twice for the two extremes of capacitance value.

The minimum frequency will be obtained when  $C$  is at its maximum value i.e. 60pF, so

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$f_{o(\min)} = \frac{1}{2\pi\sqrt{10 \times 10^{-3} \times 60 \times 10^{-12}}}$$

$$f_{o(\min)} = \frac{1}{2\pi\sqrt{6 \times 10^{-13}}} = 205468 \text{ Hz} \approx 205 \text{ kHz}$$

The maximum frequency will be obtained when  $C$  is at its minimum value i.e. 20pF, so

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$f_{o(\max)} = \frac{1}{2\pi\sqrt{10 \times 10^{-3} \times 20 \times 10^{-12}}}$$

$$f_{o(\max)} = \frac{1}{2\pi\sqrt{2 \times 10^{-13}}} = 355881 \text{ Hz} \approx 356 \text{ kHz}$$

The tuning range of this tuned circuit is therefore 205 kHz - 356 kHz

- (b) i. The break frequency of the RF filter is given by the following formula  $f_b = \frac{1}{2\pi RC}$

$$f_b = \frac{1}{2\pi \times 100 \times 10^3 \times 100 \times 10^{-12}}$$

$$= 15915.49 \text{ Hz}$$

$$\approx 16 \text{ kHz}$$



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- ii. The audio frequency range broadcast on an AM transmission is limited to approximately 5 kHz. The break frequency is higher than the highest audio frequency so any audio signal that is broadcast will pass through the RF filter.

In addition the break frequency is much lower than any RF frequency that can be picked up by the receiver.

The RF filter is therefore suitable for this radio receiver.

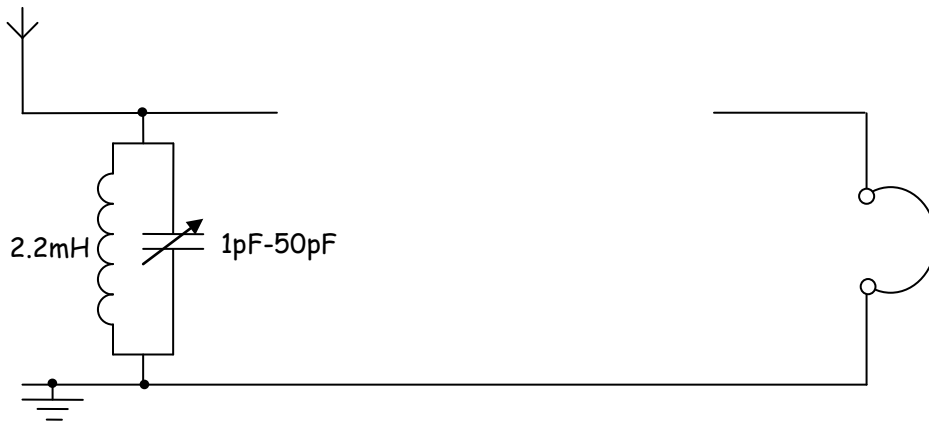
### Note for the Enthusiast

1. The break frequency of the filter is 16 kHz
2. The time constant of the filter is  $10 \mu\text{s}$
3. The period of the audio signal is  $200 \mu\text{s}$  at 5 kHz
4. The period of the carrier is a maximum of  $5 \mu\text{s}$
5. The impedance of the filter is approximately  $90 \text{ k}\Omega$

The values of  $R$  and  $C$  chosen hold up quite well when compared to the requirements stated earlier. The only exception is that the filter time constant is not long compared with the period of the carrier so a slight saw tooth effect would be superimposed on the audio signal.

The problem occurs in this case due to the relatively low carrier frequency

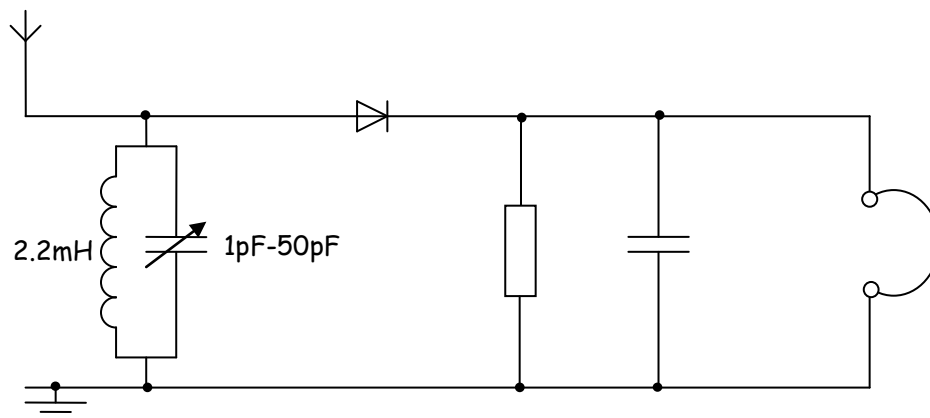
2. The following diagram shows an incomplete simple radio receiver.



- (a) Complete the circuit diagram for a simple radio receiver, (component values are not required).
- (b) The simple radio receiver is tuned to receive a radio station broadcasting on a carrier frequency of 1170 kHz.
  - (i) Calculate the value of impedance of the inductor at 1170 kHz.
  - (ii) State the value of impedance of the capacitor at 1170 kHz.
  - (iii) Calculate the value of  $C$  set on the variable capacitor to receive the radio station transmitting at 1170 kHz.
- (c) The user would like to re-tune the radio to receive a radio station transmitting on a carrier frequency of 450 kHz. Show by calculation if this is possible.

**Solution**

(a)



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- (b) (i) The impedance of the inductor at resonance is given by the formula  $X_L = 2\pi f_o L$ , where the resonant frequency = 1170 kHz.

$$\begin{aligned} X_L &= 2\pi f_o L \\ &= 2 \times \pi \times 1170 \times 10^3 \times 2.2 \times 10^{-3} \\ &= 16172.91 \Omega \\ &\approx 16173 \Omega \end{aligned}$$

- (ii) At resonance, the impedance of the capacitor will be the same as the impedance of the inductor, therefore  $X_C = 16173 \Omega$

- (iii) Either using the formula for  $X_C$

$$\begin{aligned} X_C &= \frac{1}{2\pi f_o C} \\ C &= \frac{1}{2\pi f_o X_C} \\ &= \frac{1}{2\pi \times 1170 \times 10^3 \times 16173} \\ &= 8.41 \times 10^{-12} \text{ F} \\ &= 8.41 \text{ pF} \end{aligned}$$

- or re-arranging the resonance formula.

$$\begin{aligned} C &= \frac{1}{4\pi^2 f_o^2 L} \\ &= \frac{1}{4 \times \pi^2 \times (1170 \times 10^3)^2 \times 2.2 \times 10^{-3}} \\ &= 8.41 \times 10^{-12} \text{ F} \\ &= 8.41 \text{ pF} \end{aligned}$$

- (c) Either : calculate the lowest frequency the circuit can receive.

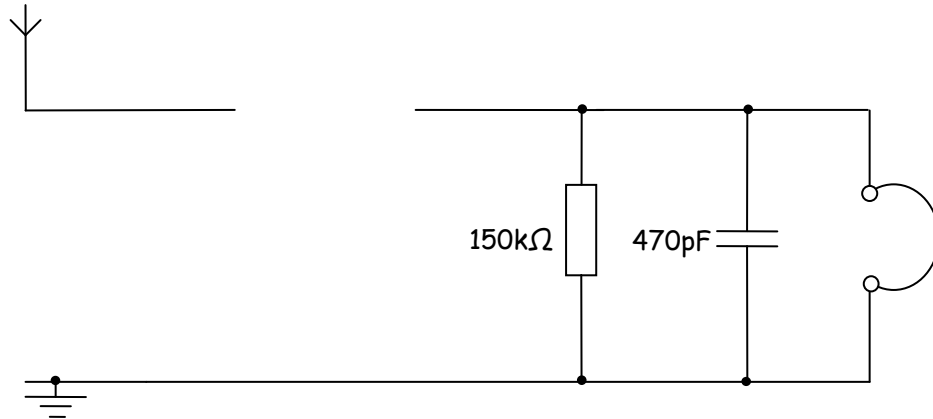
$$\begin{aligned} f_o &= \frac{1}{2\pi\sqrt{LC}} \\ &= \frac{1}{2\pi\sqrt{2.2 \times 10^{-3} \times 50 \times 10^{-12}}} \\ &= 479870 \text{ Hz} \\ &\approx 480 \text{ kHz} \end{aligned}$$

- or calculate the value of  $C$  required to receive the required station.

$$\begin{aligned} C &= \frac{1}{4\pi^2 f_o^2 L} \\ &= \frac{1}{4\pi^2 \times (450 \times 10^3)^2 \times 2.2 \times 10^{-3}} \\ &= 5.685 \times 10^{-11} \text{ F} \\ &\approx 57 \text{ pF} \end{aligned}$$

Either method shows that the station transmitting on 450 kHz cannot be received. The lowest frequency that can be received is 480 kHz, and the second method shows that  $C$  would have to be set at 57 pF to make the resonant frequency 450 kHz.

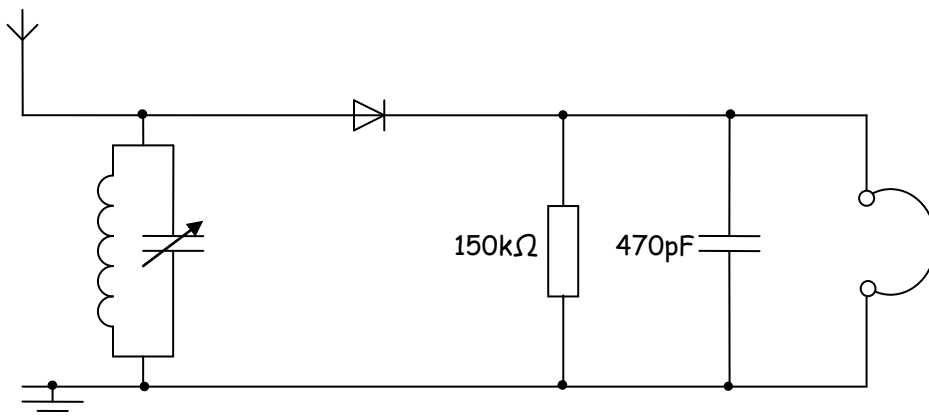
3. The following diagram shows an incomplete radio receiver.



- (a) Complete the circuit diagram for the simple radio receiver.  
(Component values are not required)
- (b) The radio receiver must receive radio signals broadcast over the frequency range 350 kHz - 1350 kHz
  - (i) Calculate the break frequency of the RF Filter.
  - (ii) Comment on the suitability of the break frequency for this particular radio receiver.

**Solution:**

(a)



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- (b) i. The break frequency of the RF filter is given by the following

formula  $f_b = \frac{1}{2\pi RC}$

$$\begin{aligned} f_b &= \frac{1}{2\pi \times 150 \times 10^3 \times 470 \times 10^{-12}} \\ &= 2257.5 \text{ Hz} \\ &\approx 2.3 \text{ kHz} \end{aligned}$$

- ii. The audio frequency range broadcast on an AM transmission is limited to approximately 5 kHz. The break frequency is much lower than the highest audio frequency transmitted, therefore frequencies above 2.3 kHz will be attenuated. The RF filter is therefore un-suitable for this radio receiver.

### Issues with the Simple Radio Receiver.

The simple radio receiver has two major problems.

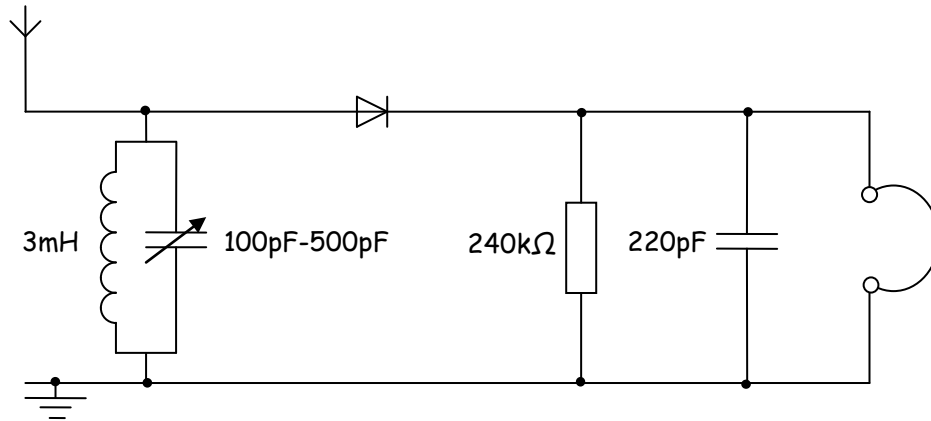
1. It is not very sensitive - radio stations have to be very strong, to generate a large enough voltage in the antenna (aerial) to switch on the germanium diode. That is it cannot pick up weak stations.
2. It is not very selective - using a single tuned circuit it is difficult to obtain a high Q-factor which makes it difficult for the radio to select a single station without picking up a signal from any neighbouring stations and thus causing interference where two overlapping sounds can be heard.

We will look at ways of improving these two flaws in our next topic - 4.2.2  
Advanced Radio Receivers

Now here are a few questions for you to try.

**Student Exercise 1**

1. The following circuit shows a simple radio receiver



(a) Calculate the minimum and maximum frequency that the tuned circuit of this radio can respond to.

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(b) (i) Calculate the break frequency of the RF Filter.

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### Topic 4.4.1 - Simple AM Receiver



- (ii) Comment on the suitability of the break frequency for this particular radio receiver.

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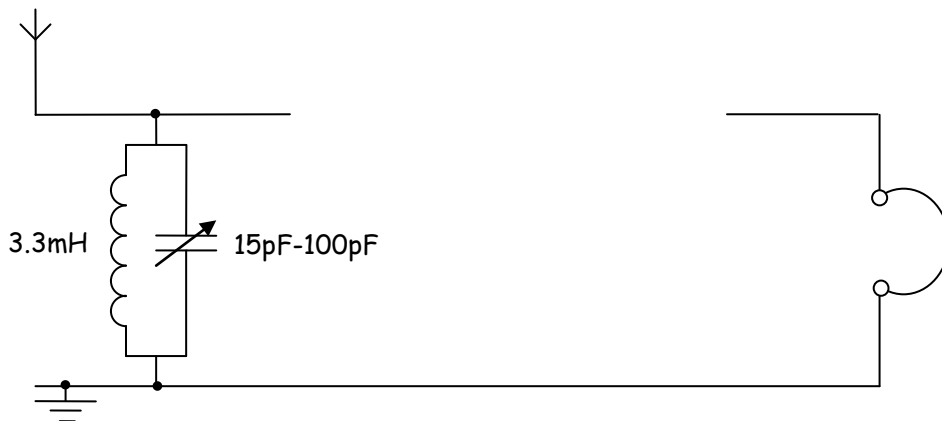
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2. The following diagram shows an incomplete simple radio receiver.



- (a) Complete the circuit diagram for a simple radio receiver, (component values are not required).
- (b) The simple radio receiver is tuned to receive a radio station broadcasting on a carrier frequency of 680 kHz.

- (i) Calculate the value of impedance of the inductor at 680 kHz.
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(ii) State the value of impedance of the capacitor at 680 kHz.

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(iii) Calculate the value of  $C$  set on the variable capacitor to receive the radio station transmitting at 680 kHz.

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(c) The user would like to re-tune the radio to receive a radio station transmitting on a carrier frequency of 350 kHz. Show by calculation if this is possible.

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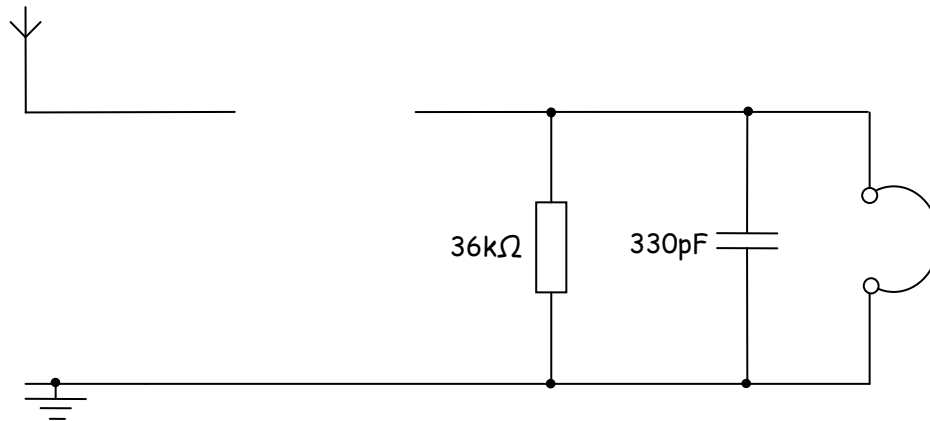
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3. The following diagram shows an incomplete radio receiver.



- (a) Complete the circuit diagram for the simple radio receiver.  
(Component values are not required)
- (b) The radio receiver must receive radio signals broadcast over the frequency range 500 kHz - 1600 kHz
  - (i) Calculate the break frequency of the RF Filter.

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- (ii) Comment on the suitability of the break frequency for this particular radio receiver.

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Solutions to Student Exercise:

1. (a) The minimum frequency will be obtained when  $C$  is at its maximum value i.e. 500 pF, so

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$f_{o(\min)} = \frac{1}{2\pi\sqrt{3 \times 10^{-3} \times 500 \times 10^{-12}}}$$

$$f_{o(\min)} = \frac{1}{2\pi\sqrt{6 \times 10^{-13}}} = 129949 \text{ Hz} \approx 130 \text{ kHz}$$

The maximum frequency will be obtained when  $C$  is at its minimum value i.e. 100pF, so

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$f_{o(\max)} = \frac{1}{2\pi\sqrt{3 \times 10^{-3} \times 100 \times 10^{-12}}}$$

$$f_{o(\max)} = \frac{1}{2\pi\sqrt{2 \times 10^{-13}}} = 290575 \text{ Hz} \approx 291 \text{ kHz}$$

The tuning range of this tuned circuit is therefore 130 kHz - 291 kHz

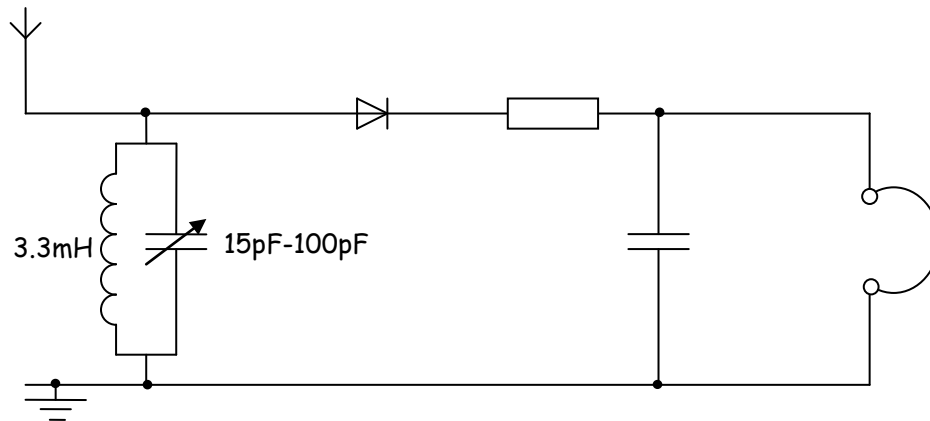
- (b) i. The break frequency of the RF filter is given by the following formula  $f_b = \frac{1}{2\pi RC}$

$$\begin{aligned} f_b &= \frac{1}{2\pi \times 240 \times 10^3 \times 250 \times 10^{-12}} \\ &= 2652.58 \text{ Hz} \\ &\approx 2.7 \text{ kHz} \end{aligned}$$

- ii. The audio frequency range broadcast on an AM transmission is limited to approximately 5 kHz. The break frequency is within the broadcast range and the RF filter is therefore unsuitable for this radio receiver.

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2. (a)



(b) (i)

$$\begin{aligned}
 X_L &= 2\pi f_o L \\
 &= 2 \times \pi \times 680 \times 10^3 \times 3.3 \times 10^{-3} \\
 &= 14099.47 \Omega \\
 &\approx 14100 \Omega
 \end{aligned}$$

(ii) At resonance, the impedance of the capacitor will be the same as the impedance of the inductor, therefore  
 $X_C = 14100 \Omega$

(iii) Either

$$\begin{aligned}
 X_C &= \frac{1}{2\pi f_o C} \\
 C &= \frac{1}{2\pi f_o X_C} \\
 &= \frac{1}{2 \times \pi \times 680 \times 10^3 \times 14100} \\
 &= 1.659 \times 10^{-11} \text{ F} \\
 &= 16.59 \text{ pF}
 \end{aligned}$$

or

$$\begin{aligned}
 C &= \frac{1}{4\pi^2 f_o^2 L} \\
 &= \frac{1}{4 \times \pi^2 \times (680 \times 10^3)^2 \times 3.3 \times 10^{-3}} \\
 &= 1.660 \times 10^{-11} \text{ F} \\
 &= 16.60 \text{ pF}
 \end{aligned}$$

(c) Either :

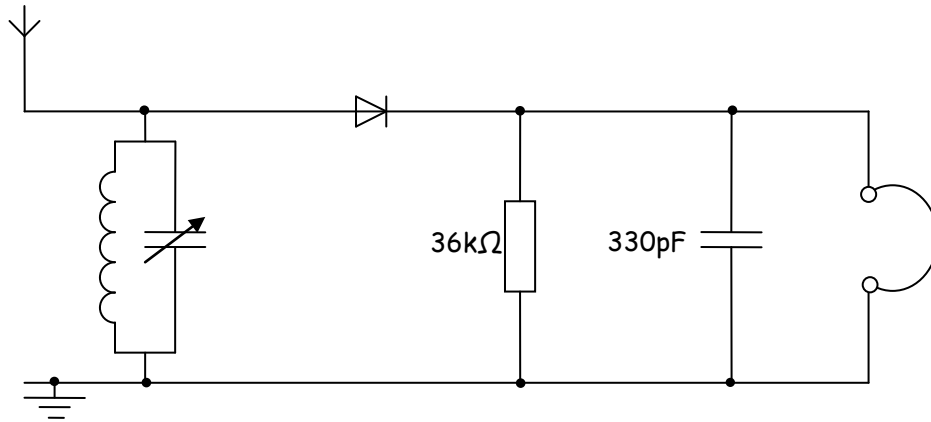
$$\begin{aligned}
 f_o &= \frac{1}{2\pi\sqrt{LC}} \\
 &= \frac{1}{2 \times \pi \times \sqrt{3.3 \times 10^{-3} \times 100 \times 10^{-12}}} \\
 &= 277053.19 \text{ Hz} \\
 &\approx 277 \text{ kHz}
 \end{aligned}$$

Or

$$\begin{aligned}
 C &= \frac{1}{4\pi^2 f_o^2 L} \\
 &= \frac{1}{4 \times \pi^2 \times (350 \times 10^3)^2 \times 3.3 \times 10^{-3}} \\
 &= 6.265 \times 10^{-11} \text{ F} \\
 &\approx 63 \text{ pF}
 \end{aligned}$$

Either method shows that the receiver can receive a frequency of 350 kHz.

3. (a)



- (b) i. The break frequency of the RF filter is given by the following formula  $f_b = \frac{1}{2\pi RC}$

$$f_b = \frac{1}{2\pi \times 36 \times 10^3 \times 330 \times 10^{-12}}$$

$$= 13396.88 \text{ Hz}$$

$$\approx 13 \text{ kHz}$$

- (ii) The audio frequency range broadcast on an AM transmission is limited to approximately 5 kHz. The break frequency is higher than the highest audio frequency so any audio signal that is broadcast will pass through the RF filter.

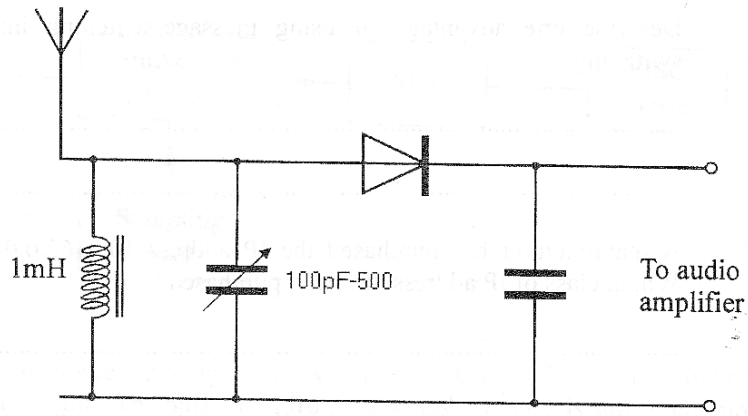
In addition the break frequency is much lower than any RF frequency that can be picked up by the receiver.

The RF filter is therefore suitable for this radio receiver.

Now for some examination style questions.

**Examination Style Questions**

1. The following shows the circuit diagram for a simple radio receiver.



a) Calculate the lowest frequency to which the receiver can respond.

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[3]

b) Describe and explain the part played by the following components in this receiver.

i) The diode

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[2]

ii) The fixed capacitor

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[2]

## Topic 4.4.1 - Simple AM Receiver



2. A simple radio receiver consists of the following sub-systems:

*detector      antenna      headphones      RF filter      tuned circuit*

(a) Draw the block diagram for this receiver.

[1]

(b) (i) Name the component used as the detector, which modifies the RF signal to give a non-zero average audio signal voltage.

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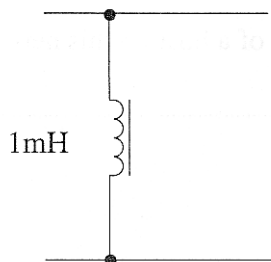
[1]

(ii) Name the component used as a demodulator, which separates the audio signal from the RF carrier.

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[1]

(c) Here is part of the circuit diagram for the tuned circuit.



(i) Complete the diagram by adding the second component needed to allow the user to select different radio stations.

[1]

- (ii) Choose a suitable range of values for this second component to allow the receiver to tune to radio broadcasts in the frequency range 500 kHz to 1000 kHz.  
**You must give the correct unit with your answer.**

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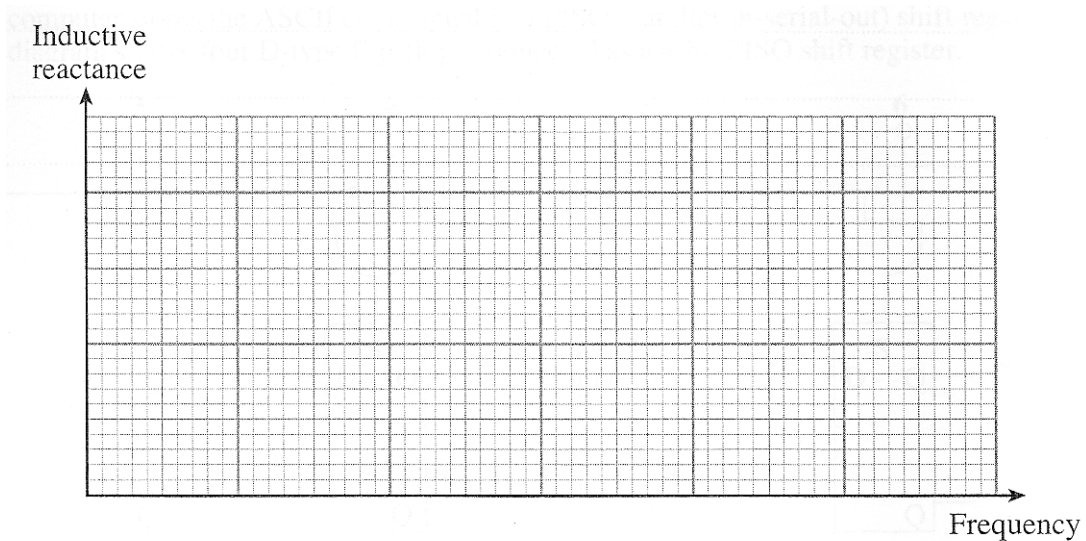
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- (iii) The receiver is tuned to an AM radio station broadcasting on a carrier frequency of 800 kHz. The radio station broadcasts a signal ranging in frequency from 40Hz to 4 kHz. What is the lowest frequency the tuned circuit must respond to, in order to receive this signal?

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- (iv) Sketch a graph to show how the inductive reactance of the inductor changes with frequency.



- (v) At the resonant frequency of the tuned circuit, what is significant about the reactance of the inductor and the reactance of the capacitor ?

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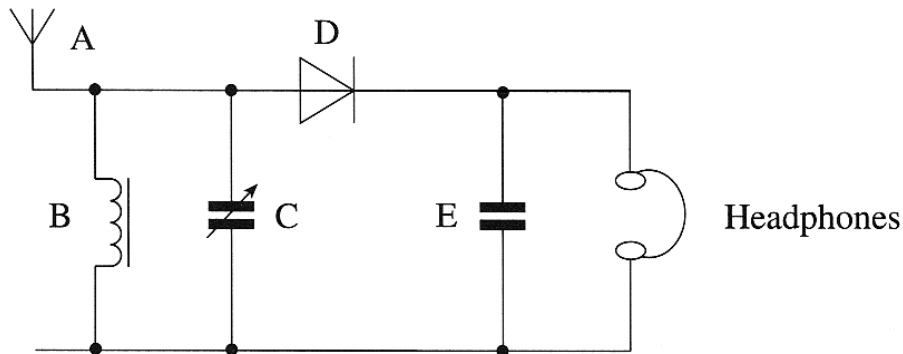
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### Topic 4.4.1 - Simple AM Receiver

3. Here is the circuit diagram for a simple radio receiver.



(a) What is the name of the sub-system made up of components B and C?

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(b) Component E is a 20nF capacitor.

(i) Calculate its reactance at a frequency of 200 kHz. Give the correct unit for your answer.

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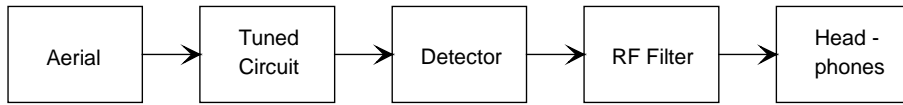
(ii) Estimate its reactance at audio frequencies.

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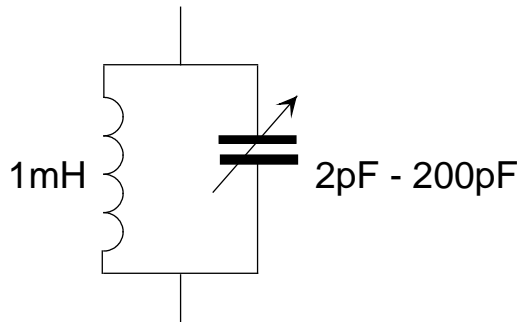
(iii) Hence explain how the system demodulates the AM signal.

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4. Here is a block diagram of a simple radio receiver.



a. The circuit diagram of the *Tuned circuit* is shown below.



i) Radio Wales transmits on a carrier frequency of 882 kHz. Calculate the reactance of the inductor at 882 kHz. Give the unit. [2]

.....

.....

.....

ii) What should the reactance of the variable capacitor be if the circuit is to pick up Radio Wales. [1]

.....

iii) Calculate the value of the variable capacitor when receiving Radio Wales. [2]

.....

.....

.....

b. Name the component used as the detector in the simple radio receiver. [1]

.....

## Topic 4.4.1 - Simple AM Receiver



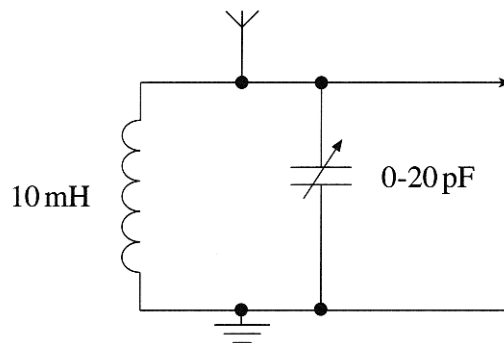
5. A tuned circuit is used in a radio receiver to select the desired radio signal from a range of signals present in the aerial.

- a) The receiver is tuned to receive a carrier frequency of 1170 kHz with base bandwidth of 10 kHz. Sketch the frequency response required from the tuned circuit on the axes below. Label all **relevant frequencies**.

[2]



- b) The following circuit diagram shows a suitable tuned circuit.



The radio is tuned to receive a carrier frequency of 1170 kHz.

- i) Calculate the reactance of the inductor.

[1]

.....

.....

- ii) What is the reactance of the variable capacitor for maximum signal output ?

[1]

.....

- iii) Calculate the value of the variable capacitor for maximum signal output.

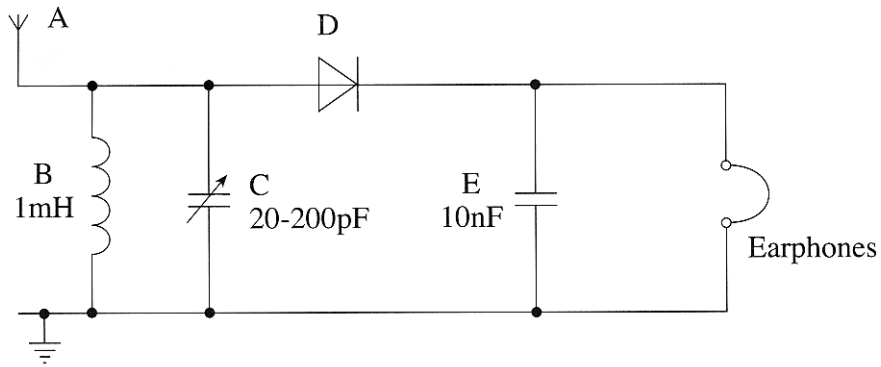
[2]

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.....

6. The circuit diagram for a simple radio receiver is shown below.



a. Use the letters A - E to answer the following questions.

- i) Which component(s) modifies the RF signal to give a non-zero average audio signal. ....
- ii) Which component(s) select the required RF signal ..... [4]
- iii) Which component carries more than one RF signal ..... [4]

b. Calculate the highest frequency to which the above receiver can respond.

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.....

.....

[3]

c. The earphones and 10nF capacitor form the low pass filter for the radio. The impedance of the earphone is 1.2MΩ.

- i. Calculate the break frequency of the filter.  
.....  
.....

[2]

ii. State with reasons whether this RF filter is effective in this case.

.....

.....

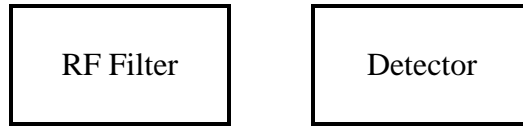
.....

[2]

## Topic 4.4.1 - Simple AM Receiver



7. The simple radio receiver is made from **five** functional blocks. Two of the blocks are shown below.



- a) In the space below draw a block diagram to show how these blocks are connected together to make a crystal radio receiver.

[4]

- b) What component is used in the detector block ?

[1]

.....

- c) What component is used in the RF Filter block ?

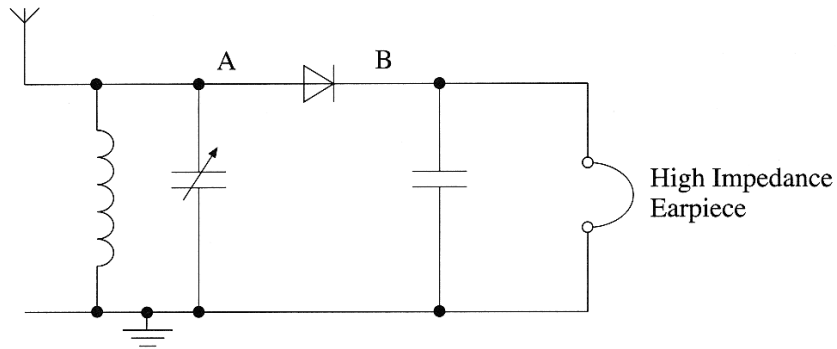
[1]

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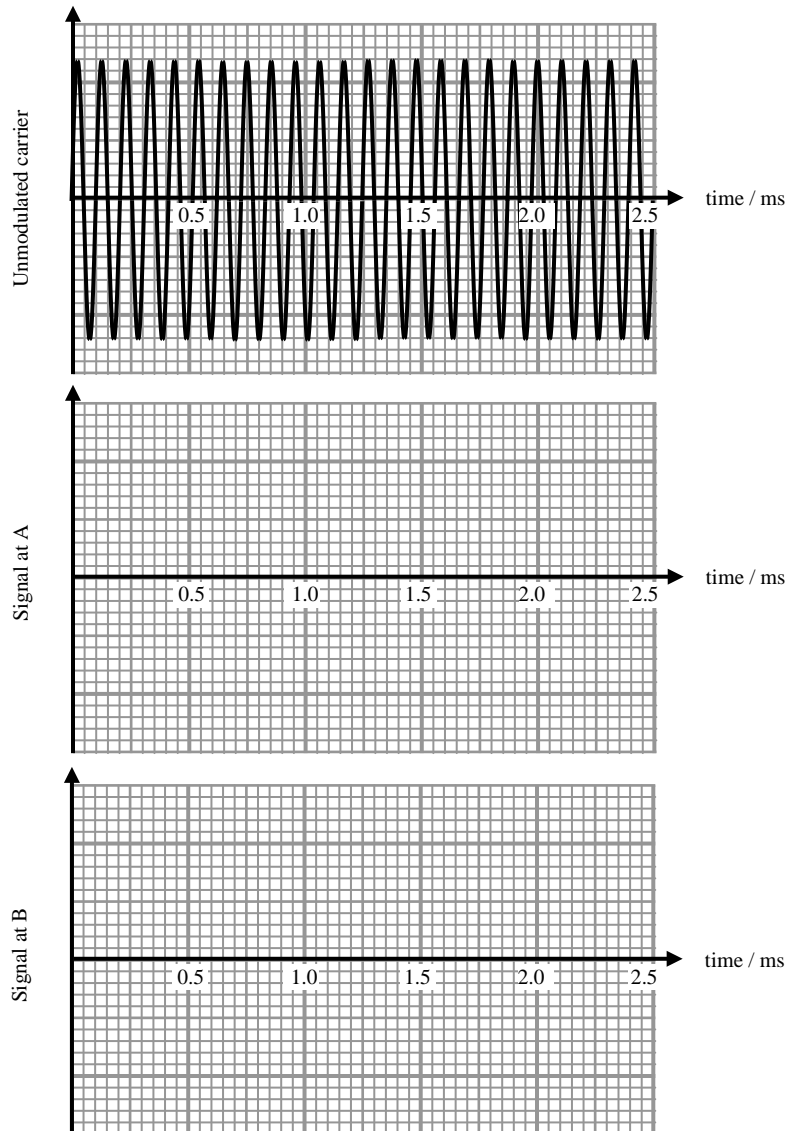


## Topic 4.4.1 - Simple AM Receiver

8. The following shows the circuit diagram for a simple radio receiver.

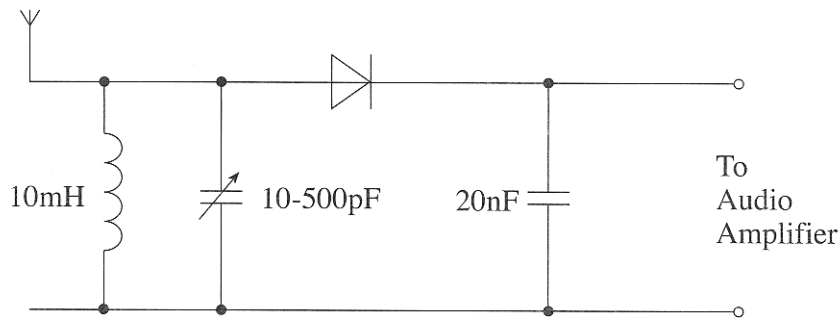


The receiver is tuned to receive a 1 kHz sine wave test signal, amplitude modulated onto a 100 kHz carrier wave. Sketch the waveform you would expect to see on an oscilloscope at points A and B.



[3]

9. The following shows the circuit diagram for a simple radio receiver.



a. Explain the purpose of the following components in this receiver.

i) The inductor and variable capacitor.

.....

.....

.....

[1]

ii) The diode.

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.....

[1]

iii) The fixed capacitor.

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[1]

b. Calculate the highest carrier frequency that the receiver can select. Give the unit.

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[3]

[3]



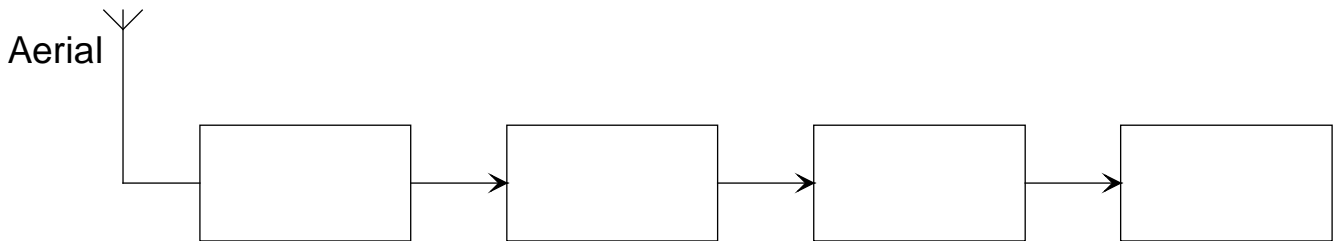
## Topic 4.4.1 - Simple AM Receiver



10. A simple radio receiver is made from the following sub-systems.

*Detector*                      *Tuned Circuit*                      *Headphones*                      *RF Filter*

- a. i) Complete the block diagram of the simple radio receiver, using the subsystems above.

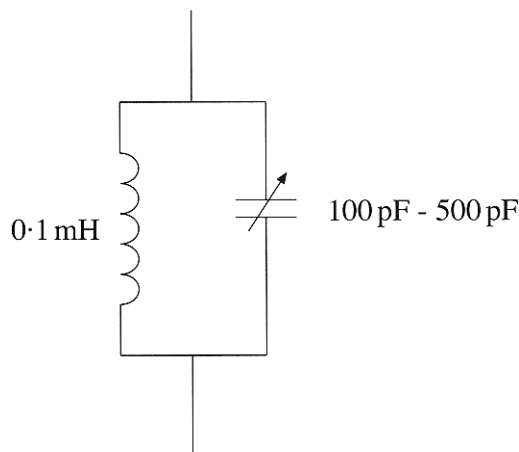


[1]

- ii) Name the component used as the detector in the simple radio receiver.

.....  
[1]

b. The circuit diagram of the *tuned circuit* is shown below.



- i) *Valleys Radio* transmits on a carrier frequency of 999 kHz. Calculate the reactance of the inductor at 999 kHz. Give the unit.

[3]

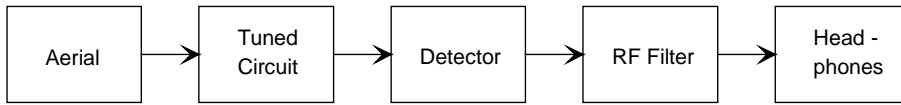
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## Module ET4 - Communication Systems

- ii) State the reactance of the variable capacitor when the circuit is tuned to pick up *Valleys Radio*. [1]  
.....
- iii) Calculate the value of the variable capacitor when receiving *Valleys Radio*. [2]  
.....  
.....  
.....
- c. The simple radio receiver suffers from poor *selectivity* and *sensitivity*. What is meant by poor *sensitivity*? [1]  
.....  
.....  
.....

## Topic 4.4.1 - Simple AM Receiver

11. Here is a block diagram of a simple radio receiver.

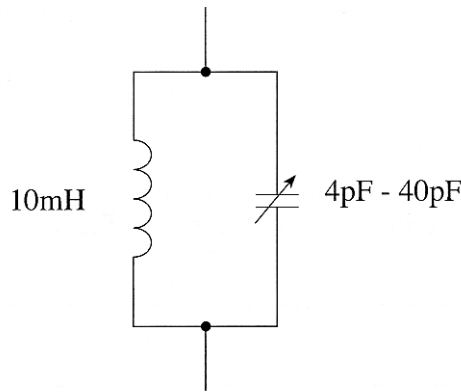


a. Name the component used as the detector in the simple radio receiver.

[1]

.....

b. The circuit diagram of the *Tuned circuit* is shown below.



i) Radio Five Live transmits on a carrier frequency of 693 kHz. Calculate the reactance of the inductor at 693 kHz. Give the unit.

[2]

.....  
 .....  
 .....

ii) What is the reactance of the variable capacitor at 693 kHz?

[1]

.....

iii) Calculate the value of the variable capacitor when tuned to receive Radio Five Live, at 693 kHz.

[2]

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 .....  
 .....

- iv) Radio Five Live also broadcasts on 909 kHz. Show by calculation whether this tuned circuit can be adjusted to receive Radio Five Live at 909 kHz.

[2]

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.....  
.....

- c. The simple radio receiver suffers from *poor selectivity* and *poor sensitivity*. What is meant by the terms *poor selectivity* and *poor sensitivity*?

*Poor selectivity* means .....

.....  
.....

*Poor sensitivity* means .....

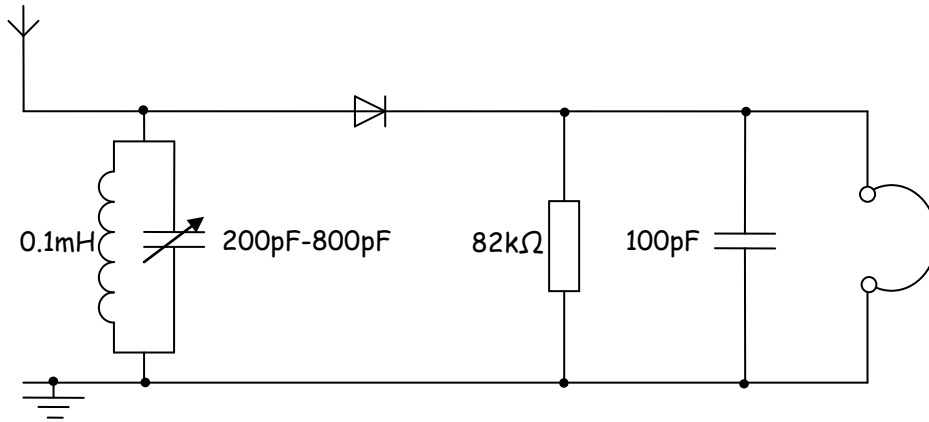
.....  
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[2]

## Topic 4.4.1 - Simple AM Receiver



12. The following circuit shows a simple radio receiver



(a) Calculate the minimum and maximum frequency that the tuned circuit of this radio can respond to.

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[3]

(b) (i) Calculate the break frequency of the RF Filter.

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[2]

(ii) Comment on the suitability of the break frequency for this particular radio receiver.

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[2]



## Module ET4 - Communication Systems

- (c) The user would like to re-tune the radio to receive a radio station transmitting on a carrier frequency of 475 kHz. Show by calculation if this is possible.

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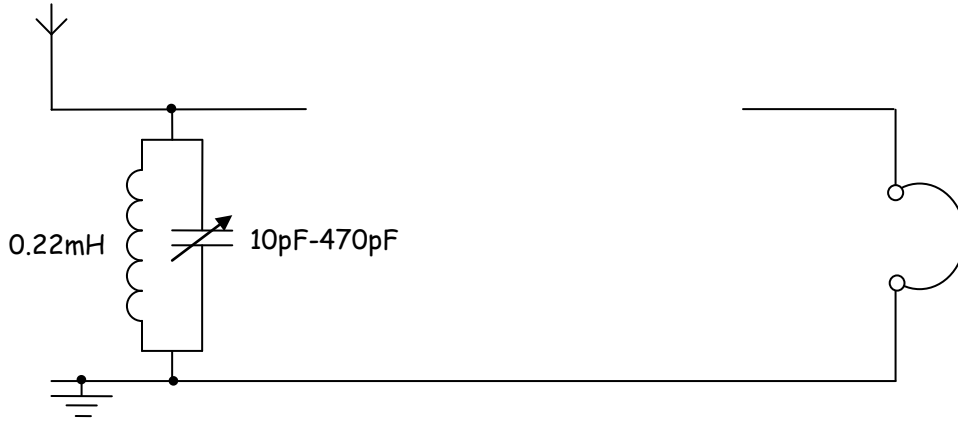
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[3]

## Topic 4.4.1 - Simple AM Receiver



13. The following diagram shows an incomplete simple radio receiver.



- (a) Complete the circuit diagram for a simple radio receiver, (component values are not required).
- (b) The simple radio receiver is tuned to receive a radio station broadcasting on a carrier frequency of 2340 kHz.

(i) Calculate the value of impedance of the inductor at 2340 kHz.

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[2]

(ii) State the value of impedance of the capacitor at 2340 kHz.

.....

[1]

(iii) Calculate the value of C set on the variable capacitor to receive the radio station transmitting at 2340 kHz.

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Self Evaluation Review

Learning Objectives	My personal review of these objectives:		
			
draw a block diagram, and circuit diagram for a simple radio receiver, consisting of antenna, tuned circuit, detector/demodulator, and earphones;			
describe the function of each of these sub-systems;			
appreciate that a tuned circuit is a variable frequency band pass filter;			
design a tuned circuit to select a particular carrier frequency;			
select and use the equation $C = \frac{1}{4\pi^2 f_o^2 L}$ to calculate the value of C to provide a given resonant frequency.			
use the frequency response curves of a loaded tuned circuit to explain poor selectivity.			

Targets: 1. ....  
 .....  
 2. ....  
 .....