

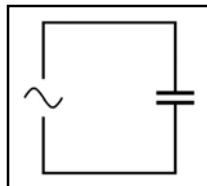
# Reactance and Impedance

YOU WILL NO doubt recall that when current passes through a resistor it opposes the flow of the current and that Ohm's law describes the relationship between the potential difference, the current and the resistance. With alternating current we saw that Ohm's law was still valid but that we had to use RMS values for the potential difference and the current. We now need to consider how current flows in capacitors and inductors.

## Reactance in capacitors (3f.2)

WHEN CAPACITORS REPEATEDLY charge and discharge they do not all pass the alternating current equally well; they provide some opposition to the current, a bit like the resistance offered by resistors. However, to distinguish the properties of capacitors from those of resistors, the opposition to current flow in a capacitor is not referred to as resistance but is known as *reactance*. The symbol for reactance is  $X$ .

You will need to remember that reactance is defined as 'the ratio of the RMS potential difference to the RMS current as the capacitor stores and releases energy in the form of an electric field'. In other words, Ohm's law can be used to calculate reactance using the appropriate RMS values for  $V$  and  $I$  ( $X = V_{(RMS)} / I_{(RMS)}$ ). You should also note that reactance is measured in ohms. See **Figure 27**.



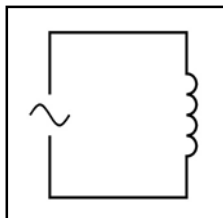
**Fig: 27** When alternating current is applied to a circuit with pure capacitance the opposition to current flow is known as (capacitive) reactance ( $X_C$ ) and is measured in Ohms.

## Reactance in inductors (3f.3)

WHEN AN ALTERNATING current flows through an inductor the magnetic field repeatedly stores and releases its energy over time as the AC changes polarity.

As the magnetic field increases and decreases, the inductance provides some opposition to the current, a bit like the resistance offered by resistors and the reactance offered by capacitors. As with capacitors, the opposition to current flow in an inductor is not referred to as resistance but is known as *reactance* ( $X$ ). In order to differentiate reactance in capacitors and inductors the properties are normally referred to as 'capacitive reactance', shown as  $X_C$ , and 'inductive reactance', shown as  $X_L$ .

You will need to remember that reactance in an inductor is defined as 'the ratio of the RMS potential difference to the RMS current as the inductor stores energy in the form of a magnetic field'. Again, Ohm's law can be used to calculate reactance using the appropriate RMS values for  $V$  and  $I$  ( $X = V_{(RMS)} / I_{(RMS)}$ ). You should also note that inductive reactance is also measured in ohms. See **Figure 28**.



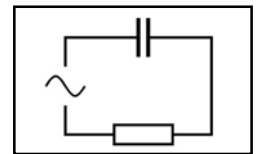
**Fig: 28** When alternating current is applied to a circuit with pure inductance the opposition to current flow is known as (inductive) reactance ( $X_L$ ) and is measured in Ohms.

## Impedance (3f.4)

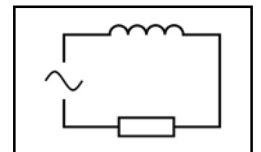
WE HAVE SEEN that resistors, capacitors and inductors can all oppose the flow of an alternating current. We now know that the opposition can be from resistance ( $R$ ), when a resistor is in the circuit, or reactance ( $X$ ) if a capacitor or an inductor is in the circuit. There is one more circuit that we need to consider; where there is a combination of resistance and reactance. See **Figures 29 and 30**.

In a circuit that includes resistors and capacitors, or resistors and inductors, a current flowing through it will result in some energy transfer (into heat) in the resistors and some energy storage and release in the capacitors or inductors. The combination of the components will oppose the flow of current and hence the transfer and storage of energy. It should be fairly obvious that the opposition will be a combination of resistance and reactance but even though they are both measured in ohms they cannot be merely added together. The correct term for this combined opposition is *impedance*. The Symbol for impedance is  $Z$ .

You need to remember that in a circuit that exhibits both resistance and reactance the ratio of the overall potential difference to the current is termed 'impedance', that impedance denotes an opposition to current flow as a result of both energy transfer and energy storage in the circuit and finally, that impedance is also measured in ohms. Once again, Ohm's law can be used where  $Z = V_{(RMS)} / I_{(RMS)}$ .



**Fig 29.** When alternating current is applied to a circuit containing both resistance and capacitive reactance the opposition it current is known as Impedance ( $Z$ ).



**Fig 30.** When alternating current is applied to a circuit containing both resistance and inductance reactance the opposition it current is known as Impedance ( $Z$ ).

## Some examples

YOU MAY BE ASKED to do some calculations using reactance or impedance values in the exam. Remember that you must use the RMS values for potential difference and current.

1. If a current of  $0.5A_{(RMS)}$  were flowing in an inductor with a reactance of  $10\Omega$  what would the potential difference across the inductor be? By transposing the formula we see that  $V_{(RMS)} = I_{(RMS)} \times X_L = 0.5 \times 10 = 5V_{(RMS)}$ .
2. If a capacitor has  $500V_{(RMS)}$  across it with a current of  $0.2A$  flowing through it, what is its reactance? Quite straightforward this time,  $X_C = V_{(RMS)} / I_{(RMS)} = 500 / 0.2 = 2500$  or  $2.5k\Omega$
3. If  $100V_{(RMS)}$  were measured across a circuit with an impedance of  $50\Omega$ , what would the current be? Again, we need to transpose the formula so that  $I_{(RMS)} = V_{(RMS)} / Z = 100 / 50 = 2A_{(RMS)}$ .