Tuned circuits

Capacitors with inductors (3g.1)

WHEN A CAPACITOR AND an inductor are joined together they form a 'tuned circuit'. Let's consider how the current might flow in such a circuit .

If we assume that the capacitor starts with a fully charged electric field when an inductor is connected to it, its energy will cause a current to flow into the inductor, which will store the energy in its magnetic field, discharging the capacitor in the process.

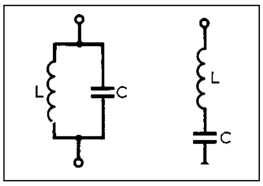

Fig 31 Parallel and series tuned circuits.

Once the capacitor is fully discharged, the current flow into the inductor will cease and the energy stored in the magnetic field then transfers back to the capacitor, charging it up again but on the opposite side.

When all of the energy stored in the inductor's magnetic field has been transferred the current flow will cease, the magnetic field will be back to zero and the sequence will repeat all over again but in the reverse direction.

This is a bit like an electrical version of a child's swing. At the top of its travel energy is stored as potential energy. This encourages it to descend, gathering speed as it does so. By the time the swing reaches the bottom of its travel the potential energy has all been converted to kinetic energy – the energy of motion. Kinetic energy makes the swing climb up the other side, but as it does so the kinetic energy is converted back to potential energy. This process repeats, but gradually decays until eventually the swing comes to rest.

Resonant frequency (3g.2)

THE FREQUENCY AT which a capacitor and a coil transfer energy back and forth is known as the 'resonant frequency'. Depending on the quality of the components involved, the circuit may only be resonant on a very specific frequency or it may be resonant over a narrow band of frequencies. At all other non-resonant frequencies the components will act independently.

The resonant frequency of a tuned circuit depends on the values of the capacitor and the inductor, so changing the value of either component will have an effect on the resonant frequency. At this level you are not expected to calculate the resonant frequency of a tuned circuit but you are expected to know that increasing the value of either the inductance (L) or the capacitance (C) reduces the resonant frequency and vice-versa.

So, if a tuned circuit is resonant at 3.6MHz and you wanted it to be resonant at 3.5MHz you would need to either increase the value of the inductor or add some more capacitance to the circuit. Increasing both would shift the resonant frequency even lower. Conversely, if you wanted it to be resonant further up the band, say at 3.8MHz, you would need to reduce the value of the inductor or the value of capacitance in the circuit. Reducing both would move the resonant frequency even higher.

If you increase one value and reduce the other the outcome is less obvious and a calculation would be required to work out the new resonant frequency. Such calculations form part of the Advanced level training and you need no knowledge of the resonant frequency formula for the Intermediate exam.

Accepting and rejecting current flow (3g.3)

A CAPACITOR AND inductor can be arranged in series or in parallel, as **Figure 31** shows. Both combinations form tuned circuits but they act in very different ways. It is worth noting that there will be some resistance in the inductor and both the inductor and the capacitor will exhibit some reactance. As you no doubt recall, where we have resistance and reactance we use the term impedance to describe the combined opposition to current flow.

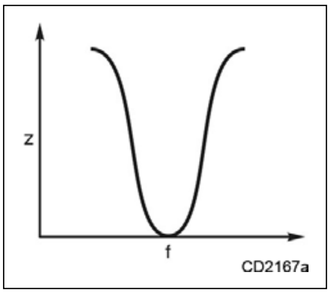

Fig 32: Impedance curve for series tuned circuit; low impedance at resonance allows energy transfer, high impedance at all other frequencies prevents energy transfer (sometimes known as accepter circuit).

The series tuned circuit is sometimes referred to as an 'acceptor' circuit, because it presents a *low* impedance at its resonant frequency. In other words, it allows current to flow at the resonant frequency, whilst resisting the flow at other frequencies. Such a circuit might be useful at the input to a receiver, to aid selection of the wanted frequency, or indeed to pass to earth, a strong unwanted signal. See **Figure 32**.

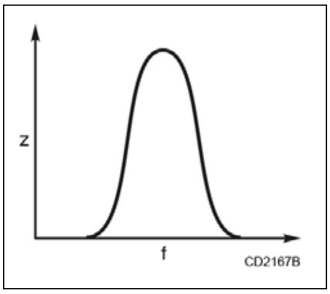

Fig 33: Impedance curve for parallel tuned circuit; high impedance at resonance prevents energy transfer, low impedance at all other frequencies allows energy transfer (sometimes known as rejecter circuit).

The parallel tuned circuit is sometimes referred to as a 'rejector', because it presents a *high* impedance at its resonant frequency. In other words, it resists current at the resonant frequency, whilst allowing the flow at other frequencies. One place that such a circuit is found is in a trap dipole (**Fig 34**). If a radio signal is applied to the antenna and its frequency is the same as the resonant frequency of the rejector circuits, their high impedance will isolate the outer sections of the antenna. This is because the rejector circuit will not allow any current to flow at the resonant frequency. At any other frequency the tuned circuit will allow the current to flow into the outer sections of the antenna. In this way the dipole can be tuned to work on more than one band; the inner section is tuned to one frequency and the outer one to another. Some antennas use several sets of traps to form multi-band resonant dipoles.

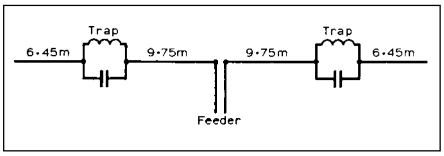

Fig 34: A trap dipole antenna contains two parallel tuned circuits.