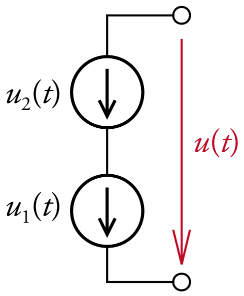
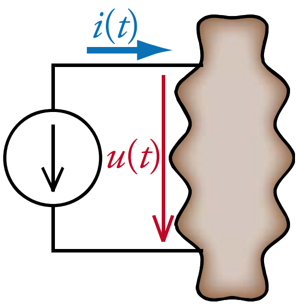
Phasors, impedances and admittances

1. Two sinusoidal voltage sources of the same frequency are series connected.
   a. Using phasors find waveform of total voltage between output terminals, if $u_1(t) = 30\sin(100\pi t), u_2(t) = 50\cos\left(100\pi t - \frac{\pi}{8}\right)$.



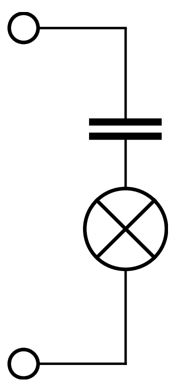
   b. Determine the phasor voltage of $u(t)$ computed in previous step when phasor magnitude is RMS value. Determine the frequency of the voltage.
   c. Convert the following voltage functions to phasors: $u_1(t) = 81.06\sin(1000t)$, $u_2(t) = -9\sin(3000t)$, $u_3(t) = -1.65\sin(5000t)$. Is possible make a sum of voltage phasors in the same way as in the question a? Simulate the waveform of total voltage in Microcap simulator, when these three voltage sources are series connected.

2. The voltage across terminals of a linear circuit is $u(t) = 30\sin(\omega t + \frac{\pi}{6})$, through circuit flows the current $i(t) = 0.2\sin(\omega t + \frac{\pi}{3})$.
   a. Calculate impedance of the circuit.
   b. Of which circuit elements (resistor / capacitor / inductor) this circuit may consist? Find value of their resistivity / capacitance / inductance, if the frequency of the source is $f = 177\,\text{Hz}$.



3. Given circuit is described by an integral differential equation:
$1000i(t) + 0.5\frac{\mathrm{d}i(t)}{\mathrm{d}t} + 10000\int_0^t i(\tau)\,\mathrm{d}\tau = 10\sin(1000t + \frac{\pi}{4})$. Using phasors calculate waveform of current in the circuit.

4. Incandescent lamp with rated voltage $U_z = 120\,\text{V}$ and rated power $P_z = 15\,\text{W}$ should be connected to power supply unit of RMS voltage $U = 230\,\text{V}$ and frequency $f = 50\,\text{Hz}$. As a device which should limit value of voltage across incandescent lamp was selected the capacitor.

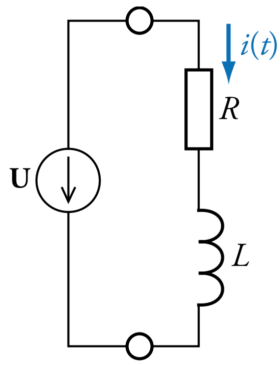


   a. Calculate the voltage across capacitor.
   b. Calculate capacitance of the capacitor.
   c. Now consider incandescent lamp with rated voltage $U_z = 12\,\text{V}$ and rated power $P_z = 18\,\text{W}$. The circuit could be connected to the distribution network in arbitrary time instant – even in AC circuit is necessary first charge the

capacitor before the phase shift will be aligned – the voltage across incandescent lamp on the instant after the circuit is switched on may be much greater than rated voltage (we will call it transient). Simulate this waveform in Microcap simulator, including the energy delivered to the incandescent lamp – ED(R1) in Transient analysis. Try to estimate risk of damage of an incandescent lamp by overvoltage.

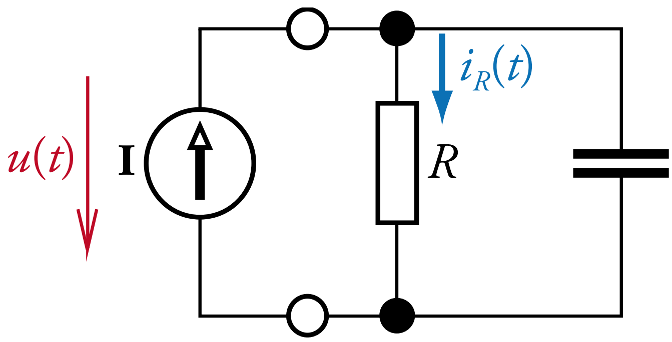
5. In the circuit in the figure calculate:
   a. Its total impedance.
   b. The waveform of current which flows through the circuit.
   c. Waveform of voltage both across resistor and inductor.

   RMS value of voltage: U = 120 V, ω = 500 s^{-1}, R = 100 Ω, L = 0.6 H.



6. In the circuit in the figure calculate:
   a. The waveform of current, that flows through the resistor.
   b. The waveform of voltage across terminals of the current source.

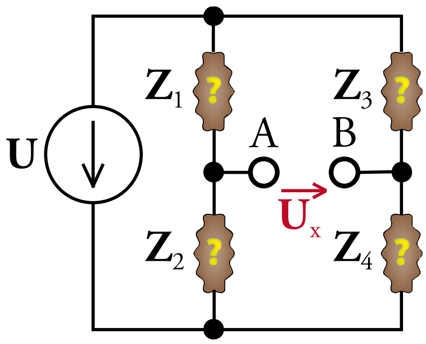
   $I_m = 10\,\mathrm{mA},\ \varphi = \frac{\pi}{4},\ \omega = 1000\,\mathrm{s}^{-1},\ R = 200\,\Omega,\ C = 4\,\mu\mathrm{F}$



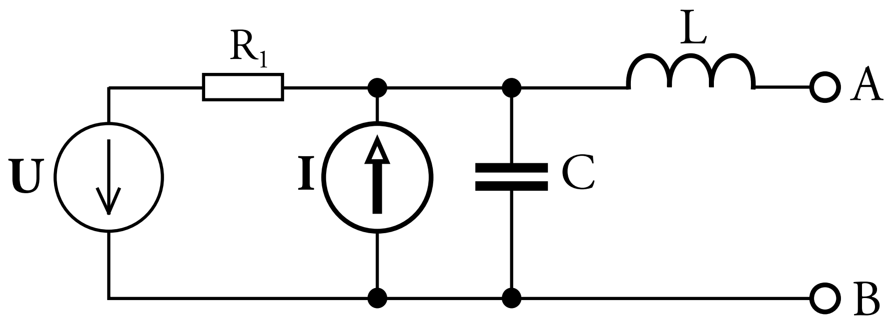
7. Connect two resistors and two capacitors in the bridge so that
   a. The phase shift between voltage of the source and $\mathbf{U}_{AB}$ voltage would be +90°.
   b. The phase shift between voltage of the source and $\mathbf{U}_{AB}$ voltage would be -45°.

   Both resistors dissipates the power $P = 1\,\mathrm{W}$. RMS voltage of the source is U = 100 V and its angular frequency ω = 1000 s^{-1}. In the case of phase shift by +90° calculate resistivity of both resistors and capacitance of capacitors.

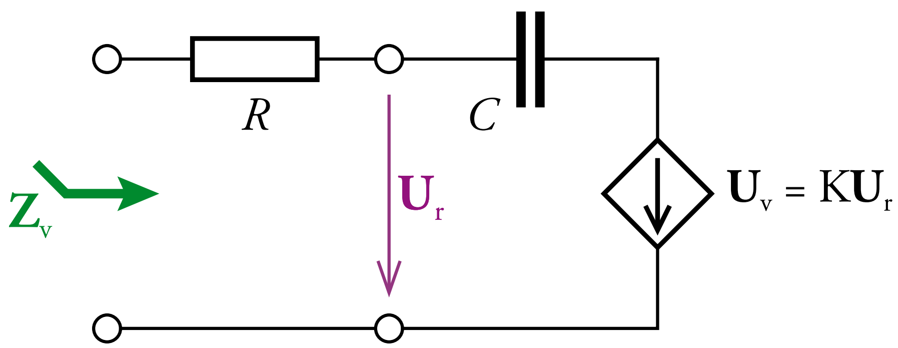
   ***Hint**: use phasor diagram of the circuit.*



8. Find the Thévenin equivalent circuit of the circuit in figure at terminals AB. Angular frequency of both sources is $\omega = 500\,\mathrm{s}^{-1}$, amplitude of voltage source $U_m = 100\,\mathrm{V}$, amplitude of current source $I_m = 50\,\mathrm{mA}$, $R = 200\,\Omega$, $C = 4\,\mu\mathrm{F}$, $L = 0.5\,\mathrm{H}$.



9. Calculate total impedance of the circuit in figure, if R = 1 kΩ, C = μF, K = -10, ω = 1000 s^{-1}.



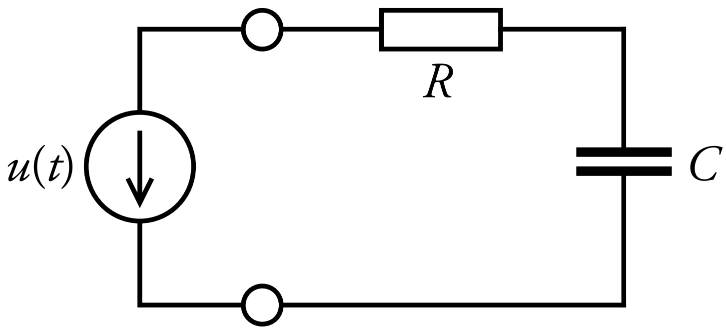
Sinusoidal steady state power analysis

1. Simplified model of fluorescent lamp (when we omit non-linear properties) is series connected inductor of inductance L = 1.37 H and resistor of resistivity R = 160 Ω. The lamp is supplied from distribution network U = 230 V, f = 50 Hz. Calculate capacitance of capacitor, which is necessary to connect in parallel to fluorescent lamp, so that the power factor of the circuit will be 95% (power factor correction). Calculate current, which the circuit drains from distribution network without power factor correction and with power factor correction capacitor.

2. In electronics shop exhibits 60 flat panel TV sets. All TV sets were connected to the same socket circuit. From energy saving reasons all TV sets are in standby mode and shop assistant always present only particular TV set. Socket circuit is protected by circuit breaker of the type B (which allows threefold greater instantaneous tripping current then the rated current is), with rated current 10 A. Surprisingly, the circuit breaker interrupts socket circuit after 10 minutes. TV set maker indicate the consumed power in standby is just 3W (so, total 180 W if 60 TV sets are connected). Determine power factor of TV set power supply in standby mode, if the switch-off current of circuit breaker after 10 minutes is 12 A? Power supply has leading reactive power (corresponding to capacitor). Design applicable power factor correction so that the corrected power factor will be 95%. Calculate the value of current drawn from power distribution grid after power factor compensation.

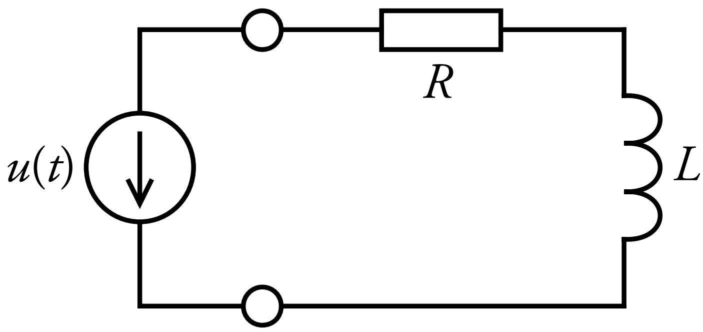
3. In the circuit in the figure below calculate active, reactive and apparent power, if the frequency of the voltage source is:
   a. $f = 50$ Hz
   b. $f = 5$ kHz

   Given values of circuit elements: $R = 1$ kΩ, $C = 1$ μF, $U_m = 100$ V.
   c. In Matlab or Microcap simulate frequency dependence of apparent power S and frequency dependence of power ratio $\frac{P}{S}$ and $\frac{Q}{S}$.



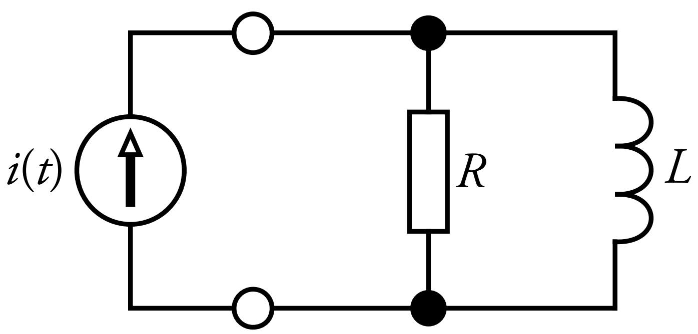
4. In the circuit in the figure below calculate active, reactive and apparent power, if the frequency of the voltage source is:
   a. $f = 500$ Hz
   b. $f = 50$ kHz

   Given values of circuit elements: $R = 1$ kΩ, $L = 10$ mH, $U_m = 100$ V.
   c. In Matlab or Microcap simulate frequency dependence of apparent power S and frequency dependence of power ratio $\frac{P}{S}$ and $\frac{Q}{S}$.



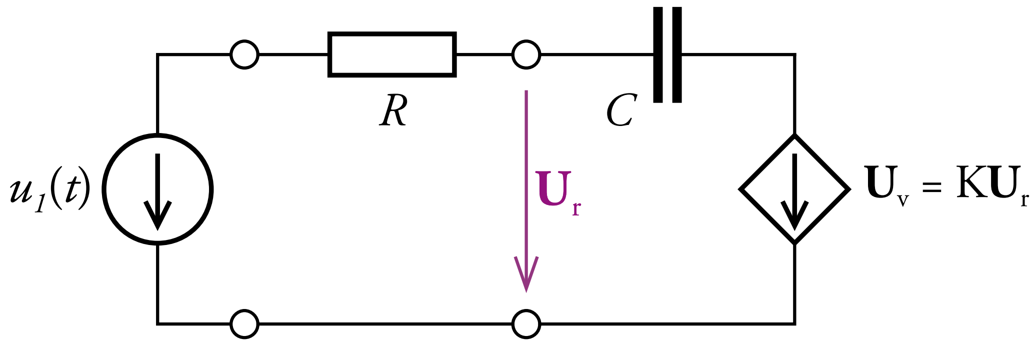
5. In the circuit in the figure below calculate active, reactive and apparent power, if the frequency of the voltage source is:
   a. $f = 100$ Hz
   b. $f = 10$ kHz

   Given values of circuit elements: $R = 1$ kΩ, $L = 50$ mH, $I_m = 100$ mA.

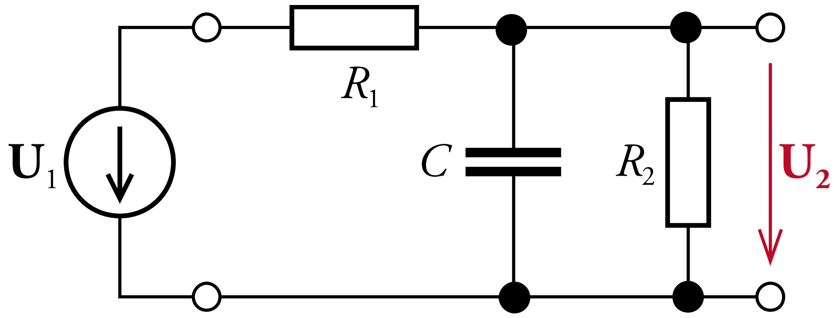


Frequency response

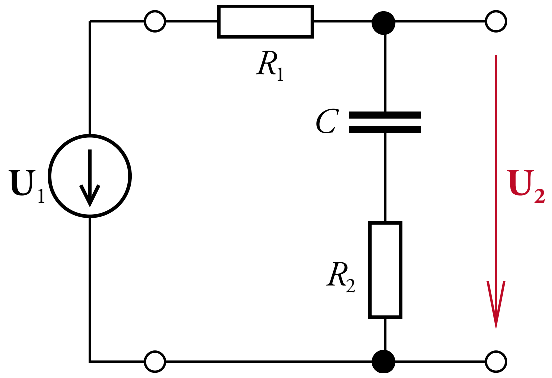
1. Given the circuit in figure below. Find break frequencies of transfer function $\mathbf{P} = \frac{\mathbf{U}_r}{\mathbf{U}_1}$. Sketch its asymptotic magnitude and phase plot (Bode plot). Draw frequency response of this circuit in Microcap simulator. R = 1 kΩ, C = 1 μF, K = -10. How affects controlled voltage source break frequency?



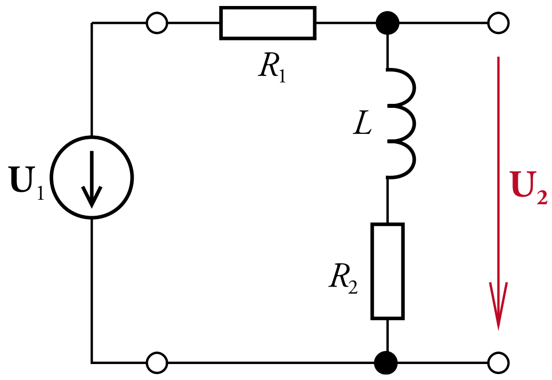
2. Given the circuit in figure below. Find break frequencies of transfer function $\mathbf{P} = \frac{\mathbf{U}_2}{\mathbf{U}_1}$. Sketch its asymptotic magnitude and phase plot (Bode plot). Draw frequency response of this circuit in Microcap simulator. $R_1 = R_2$ = 1 kΩ, C = 1 μF.



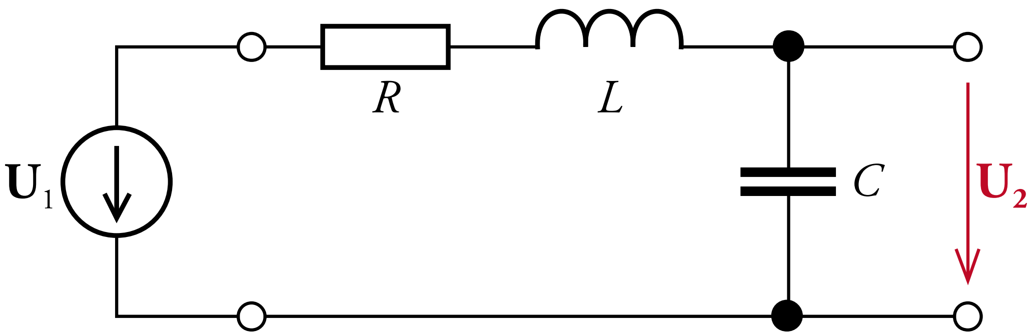
3. Given the circuit in figure below. Find break frequencies of transfer function $\mathbf{P} = \frac{\mathbf{U}_2}{\mathbf{U}_1}$. Sketch its asymptotic magnitude and phase plot (Bode plot). Draw frequency response of this circuit in Microcap simulator. $R_1 = R_2$ = 1 kΩ, C = 1 μF.



4. Given the circuit in figure below. Find break frequencies of transfer function $\mathbf{P} = \frac{\mathbf{U}_2}{\mathbf{U}_1}$. Sketch its asymptotic magnitude and phase plot (Bode plot). Draw frequency response of this circuit in Microcap simulator. $R_1 = R_2 = 1$ kΩ, $L = 10$ mH.



5. Given the circuit in figure below. Find break frequencies of transfer function $\mathbf{P} = \frac{\mathbf{U}_2}{\mathbf{U}_1}$. Sketch its asymptotic magnitude and phase plot (Bode plot) if $L = 10$ mH, $C = 1$ μF and
   a. $R = 2$ kΩ
   b. $R = 200$ Ω
   c. $R = 1$ Ω.
   d. Draw frequency response of this circuit in Microcap simulator. Using slider simulate frequency response of the circuit if resistivity varies in the range from 1 Ω to 1 kΩ in small steps.
   e. Set resistivity to $R = 1$ Ω. In Microcap simulator draw waveforms of voltage across resistor, inductor and capacitor. Be careful of correct orientation of voltage. The simulator may draw waveform of voltage both as oriented down or up, so don't use syntax V(L1), V(C1), … but use numbers of nodes, e.g. V(1,2), V(2,0). The waveform of voltage across resistor draw in one window, waveforms of voltage across capacitor and inductor draw in another window together.

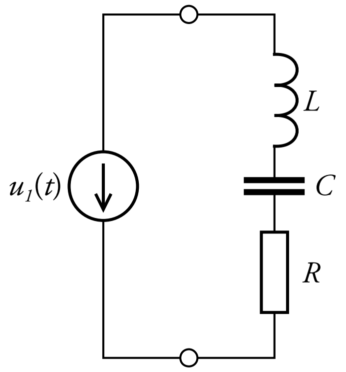


Resonant circuits

1. Series RLC circuit (see figure) is supplied from sinusoidal voltage source with amplitude 1V. Capacitance of capacitor is 1μF, inductance of an inductor is 0.1H.
   a. Find the frequency of the source (suppose it is the same as resonant frequency of the circuit) and resistivity in order to the voltage amplitude across capacitor would be 100V.
   b. Simulate waveform of voltages across distinct circuit elements in the circuit.
   Define the device voltages as voltage difference between two node voltages, e.g. V(1,2), don't specify device voltages directly V(C1), V(L1), … - MicroCap doesn't guarantee in the case of V(C1) notation the node order – it may take opposite voltage orientation, so the phase shift would be opposite (very important in resonant circuits). Time Range set at 0.5 s. Parameter of transient analysis "Maximum Time Step" set at 1u, or the resulting waveform of the

simulation would be wrong (Microcap calculate just discrete values quantized in time, similar to sampling of music for CD player).

c. Draw frequency response of this circuit in Microcap simulator.



2. Parallel RLC resonant circuit is supplied from sinusoidal voltage source with amplitude 1V. Capacitance of capacitor is 1 μF, inductance of an inductor 0.1 H, resistivity of a resistor is 10 Ω.
   a. Calculate resonant frequency of the circuit.
   b. Calculate impedance of the circuit in resonance, amplitude of current, which is drawn from the source, and current, which flows through the capacitor.
   c. Instead of voltage source assume current source of amplitude 1 mA. Calculate current which flows through the capacitor in this case and voltage across it.