

# ELECTROMAGNETIC OSCILLATIONS AND WAVES

## 1. Source of electrical oscillations parallel (R)LC circuit

This circuit can be used in tuning circuits to choose a signal with certain frequency ( $f_0$ ) or as a source of electromagnetic wave that is transmitted further.



- function :

The capacitor is charged and then disconnected. If there is no coil, it is only discharged in a very short time by a huge current. But if there is a coil, the current cannot rise quickly because of self-induction and it rises until the capacitor is discharged. Then the capacitor does not supply the current but it cannot stop immediately because of the coil. The capacitor is charged in the opposite direction and then discharged again – electrical oscillations are formed. Their period (time to get the capacitor charged again in the same polarity) depends on the inductance and capacitance.

$$X_L = X_C$$

$$\omega L = \frac{1}{\omega C}$$

$$2\pi f_0 L = \frac{1}{2\pi f_0 C}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \quad \dots \text{ natural frequency}$$

<http://www.walter-fendt.de/ph14e/osccirc.htm>

- resonance:

These electrical oscillations are damped a lot (voltage and current gradually fall, frequency stays the same). To keep the oscillations energy must be supplied from outside. The most efficient way is when the frequency of the outer signal is the same as the natural one = resonance. This can be used in tuning circuits. We can change  $f_0$  changing the capacitance, inductance or in parallel RLC circuit the resistance.

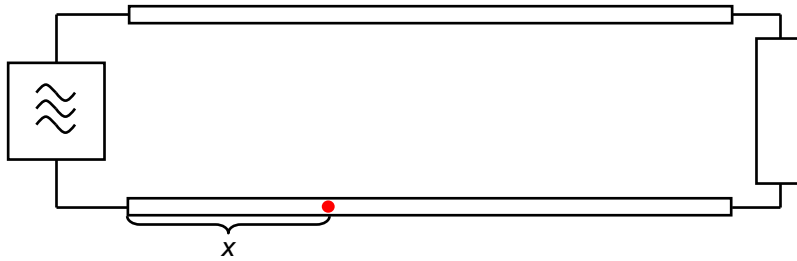
## 2. Electromagnetic waves

- a) **source** – LC OSCILLATORY CIRCUIT, but we need to transmit the energy further – waveguide is essential

The oscillator must have HIGH FREQUENCY for the points of the waveguide to be at a different phase ( $f = 375 \text{ MHz} \approx \lambda = 0.8 \text{ m}$ ;  $f = 50 \text{ Hz} \approx \lambda = 6 \text{ km!!!}$ )

$$U = U_m \sin \omega(t - \tau) = U_m \sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$$

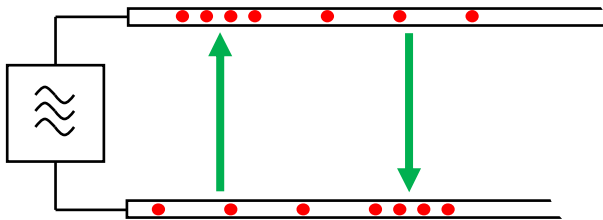
voltage  $x$  metres from the source



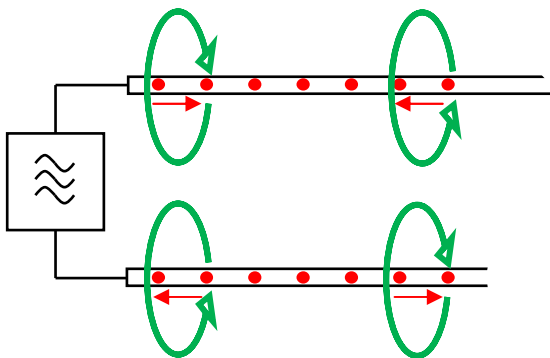
### b) electromagnetic wave

- the wave is carried by the medium AROUND the waveguide
- R at the end – PROGRESSIVE WAVE (U and I in phase)
- FREE END – energy is NOT used – reflection – STANDING WAVE (U and I out of phase!!!)

electric field around the waveguide



magnetic field around the waveguide

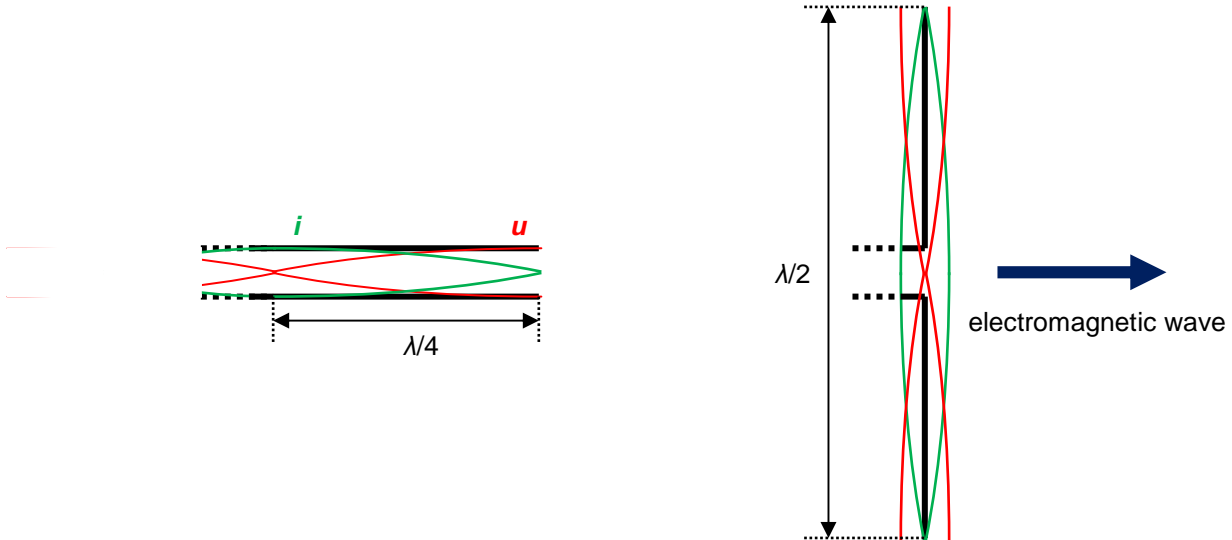


### Questions:

1. What is represented by the dots in the waveguide on the figures above?
2. Explain how and why is a magnetic and electric field formed around the waveguide.

### c) electromagnetic dipole

when we bend the ends of the waveguide as shown ( $\lambda/4 + \lambda/4 = \lambda/2$ ) the wave is sent further



## 3. Properties and transmission of electromagnetic wave

<http://en.wikipedia.org/wiki/Telecommunication>

**Communication channels** use one **carrier frequency** (bandwidth can be about 100 kHz), that is **modulated**. This means that the basic carrier frequency is changed to carry information.

Amplitude modulation (AM), amplitude-shift keying (ASK) – change amplitude of the carrier wave

[http://en.wikipedia.org/wiki/Amplitude\\_modulation](http://en.wikipedia.org/wiki/Amplitude_modulation)

Frequency modulation (FM), frequency-shift keying (FSK) – change frequency of the carrier wave

[http://en.wikipedia.org/wiki/Frequency\\_modulation](http://en.wikipedia.org/wiki/Frequency_modulation)

Phase-shift keying (PSK) – changing a phase of the carrier wave, remote controls