

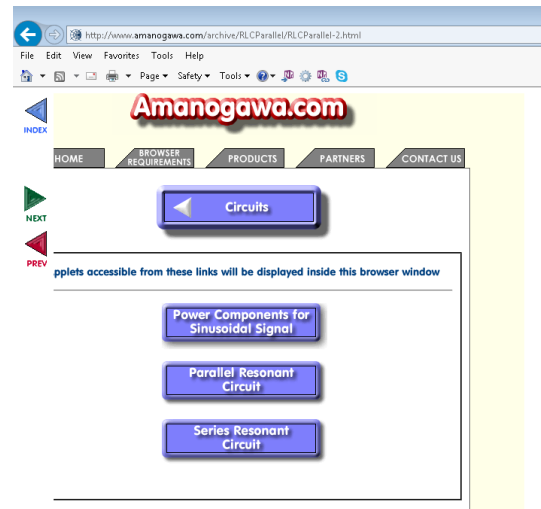
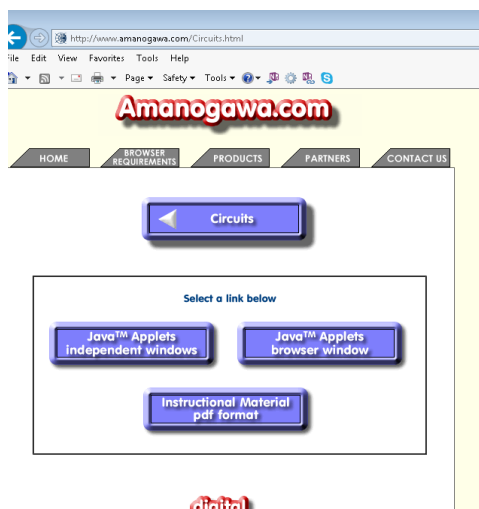
Exercises with Amanogawa Applets

RLC Parallel Circuit

- Select the Desktop shortcut or locate <http://amanogawa.com/> in the web-browser



- Select "circuits", then use the "JAVA Applets bowser window" preferably
- Now select the "Parallel Resonant Circuit", and wait until the Java applet is started...



...and you should arrive here:

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Change in the plot field (upper right corner) the setting from `Voltage and current` to `Resonance`

You see in the upper right corner of the plot (in yellow) the unloaded resonance (no impact of the generator impedance, i.e. unloaded resonator) and in green with the generator impedance included.

The generator impedance is in parallel with the loss resistor of the resonance circuit.

Now dial the `Set Impedance` field of inductance and capacitance such that you get a resonance peaking at a frequency of 1 MHz, 2 MHz and 10 MHz respectively. Keep the `R` value always at **200 Ω**.

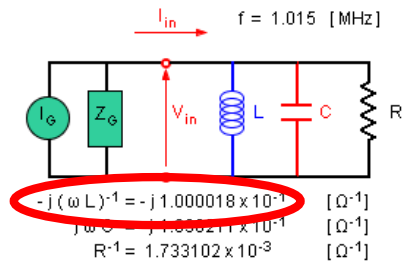
The values can only be dialled in using the sliders, the upper for the course, and the lower for the fine tuning. Note how values are changing when clicking on the arrows, ore between arrow and slider.

Note how there is an additional degree of freedom, which means there are many different combinations of L and C which result in the same resonant frequency.

This `degree of freedom` is the **characteristic impedance** of the resonator **at resonance** given by $\omega \cdot L$.

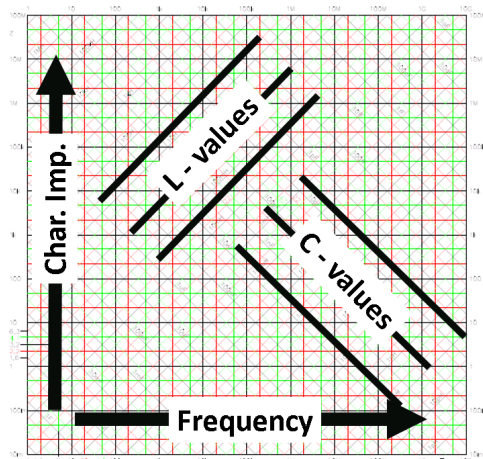
To get this parameter from the applet, 2 steps are necessary:

1. Set the frequency slider to the resonance frequency
2. Read the value indicated below. The characteristic impedance at resonance is the **inverse** of this value.



Now design a resonator with a specific resonance frequency and a specific characteristic impedance.

You may use for this purpose the attached Nomogram (`RF wall paper`).



Find the intersecting point of frequency and Characteristic impedance. Then look for diagonal lines passing close to this point. Read the L and C values from these lines and enter this initial guess into the applet. Now you can find a more accurate solution by fine tuning the values.

Note your results in the table below:

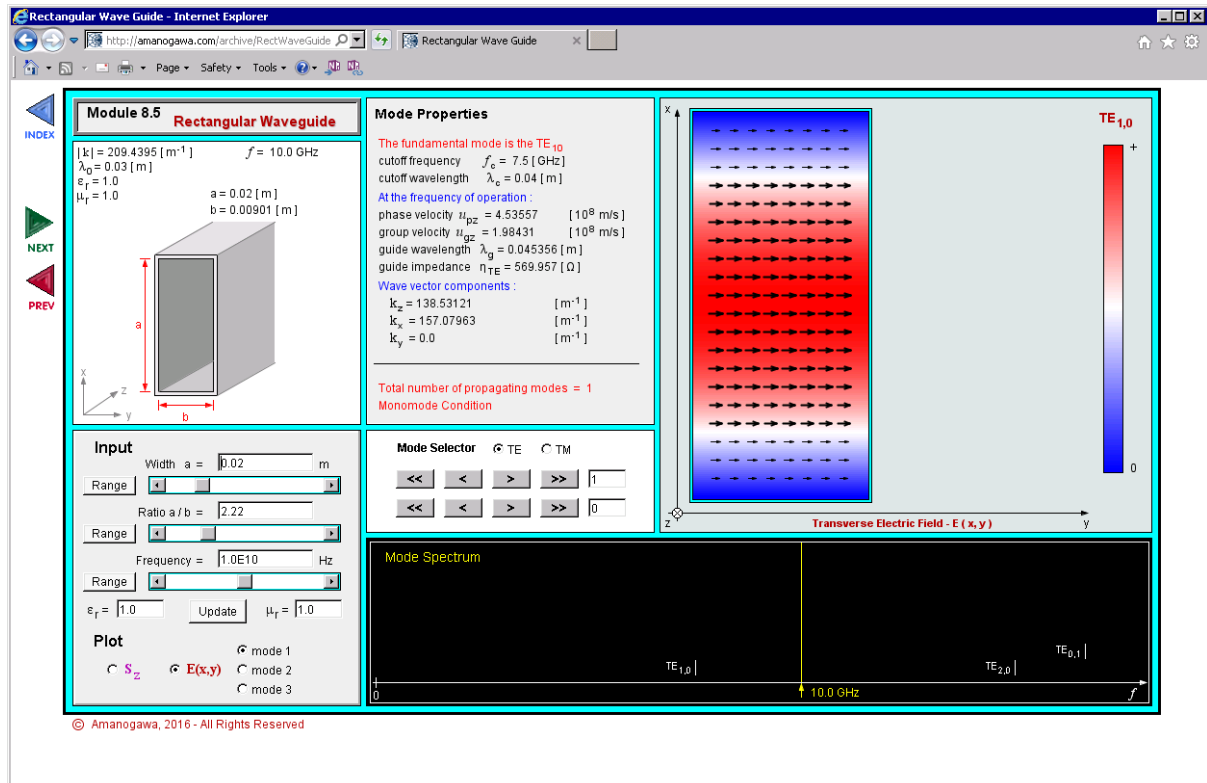
| Resonance Frequency | Char. Imp. $\omega \cdot L$ | $\frac{1}{\omega \cdot L}$ [Ω^{-1}] | R | L [H] | C [F] |
|---------------------|-----------------------------|--|---------------|-------|-------|
| 50 MHz | 32 Ω | | 10 k Ω | | |
| 11.6 kHz | 1000 Ω | | 10 k Ω | | |
| 20.0 MHz | 47 Ω | | 10 k Ω | | |
| 50 Hz | 320 Ω | | 10 k Ω | | |
| 10 MHz | 3200 Ω | | 10 k Ω | | |

Can you find a general relationship between the Characteristic impedance, the R – value and the Q factor?

Record the loaded and unloaded Q for the different cases and invent your own problem.

Modes in a Rectangular Waveguide

- Start at <http://amanogawa.com/> and follow “Electromagnetic Waves” -> “Java Applets browser window” -> “Rectangular Wave Guide”
- After successful start of the Java applets you should see this:



With help of page 16 “Mode chart of a rectangular waveguide” of the JUAS RF Course 2016 you can visualize the field pattern of the different modes in the transverse plane.

Note the chart on page 16 uses “ b/a ”, while the Java applet uses “ a/b ” as relative cross-section dimension! Also, the chart uses a different mode notation: $H_{nm} = TE_{nm}$, $E_{nm} = TM_{nm}$.

On the Java Applet

- Set Width $a = 0.08$ m
- Set Ratio $a/b = 1.25$
- Scroll or set the Frequency = 1.88 GHz (1.88E9)
- Press ‘Update’
- Under ‘**Mode Properties**’ note the values ‘cutoff frequency’ and ‘cutoff wavelength’ for the fundamental mode.
- Under ‘**Mode Selector**’ verify the selected mode is TE₁₀ and note the transverse field plot. Which field lines are shown, E-field or H-field?

Compare the mode properties results with the mode chart on the RF script page 16 and the field pattern with page 13. Use the mode chart to estimate the normalized cutoff wavelength (λ_{c0}/a) for the TE01 and TM/TE11 modes and verify the values and field patterns with the Java applet.

- Find f_c and λ_c for TE01, TE/TM11, TE20 and TE/TM21 and compare the values with the mode chart.

| a [m] | a/b | TE10 | | TE01 | | TE/TM11 | | TE20 | |
|-------|------|-------------|-----------------|-------------|-----------------|-------------|-----------------|-------------|-----------------|
| | | f_c [GHz] | λ_c [m] | f_c [GHz] | λ_c [m] | f_c [GHz] | λ_c [m] | f_c [GHz] | λ_c [m] |
| 0.08 | 1.25 | | | | | | | | |
| 0.1 | 1.67 | | | | | | | | |

Play with applet for other waveguide dimensions, e.g. $a = 0.1$ m, $a/b = 1.67$. Use the mode chart to estimate the normalized cutoff wavelength. Play with the frequency slider and change the mode selector settings to access higher order modes. Under 'Mode Properties' additional information is supplied for the selected mode, e.g. phase and group velocity for the selected actual frequency. Setting the operation frequency, e.g. near the cutoff frequency will result the phase velocity $\rightarrow \infty$, while the group velocity approaches zero.