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Attenuators

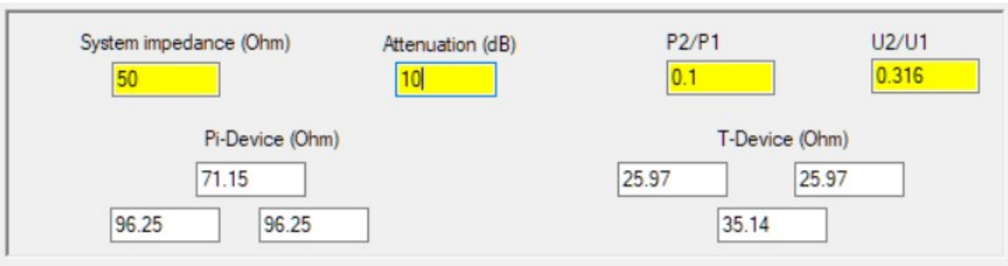
Attenuators are needed wherever too high signal voltages are to be attenuated, they usually have the same input and output impedance (usually 50Ohm) and can be realized in Pi or T circuit.

Since the amateur usually only has standardized resistance values available, the realization of the exact values can cause difficulties.
As a special feature, the tool therefore offers the possibility to find practical compromises with existing resistors, if no major accuracy requirements are made.

Example 1

In order to counteract an overload of the receiver, a 10dB attenuator is to be looped into the antenna supply line (50Ω coax cable).

You only need to enter the dB value for the power attenuation in the yellow field.
This value is always positive because it is a damping.



The ratios output to input voltage (U2/U1) and output to input power (P2/P1) are automatically updated (this also works the other way round if you enter a value in one of the other yellow fields). In the white fields, the exact resistance values for the Pi and T circuits appear immediately.

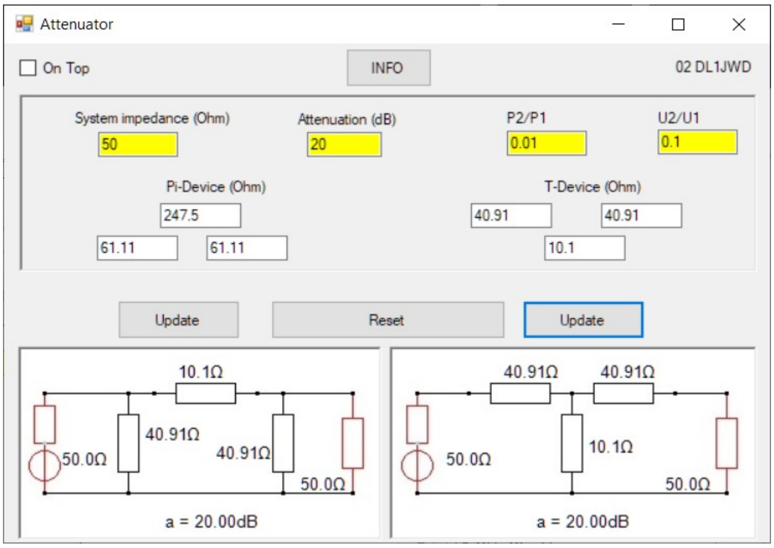
Example 2

Unfortunately, with a 10dB attenuator, the input voltage of the receiver can only be damped to 31.6%. But you want to reduce it to 10%, i.e. realize a 10:1 voltage divider (for 50Ohm termination on both sides).

For U2/U1, enter 0.1, the required power attenuation will be updated automatically, and you'll see that a 20dB attenuator is needed.
For a certain voltage damping, the attenuator must therefore be designed for twice as much power damping.

Touch the window at the bottom and zoom in.

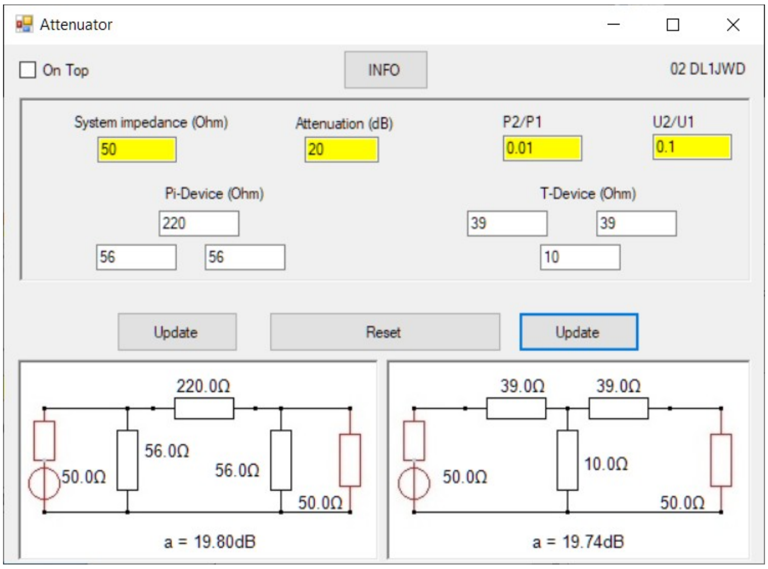
After having clicked booth "Update"-buttons you'll see the two schematics:



Example 3

The resistance values determined by the program are unfortunately quite "crooked".
How does the damping change when you use the E12 resistor series?

Enter the closest E12 series values in the white boxes and click "Update" above each circuit:



You can see how the attenuations (displayed below the circuit diagrams) change and you can decide whether the deviations are still acceptable for the specific application.
For the current example, the Pi circuit realized with 56Ω and 220Ω should come into question, as it comes closest to the desired 20dB (19.8dB).

Hints

- With the "Reset" button you can reset the switching elements to their "crooked" values.
- Since the resistances are tolerant (e.g. E12 = > 10%), it is worthwhile to measure them beforehand with a resistance bridge.

Theory

The attenuation (damping) is usually expressed in decibels (dB).
For example, if the voltage at the output has dropped to 0.707 times the value in front of the attenuator:

$$U_2/U_1 = 0.707$$

... then the voltage damping is:

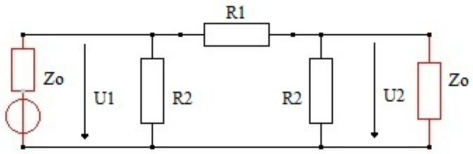
$$a_u(dB) = \mathbf{-10} * \log(0{,}707) = \mathbf{1{,}5dB}$$

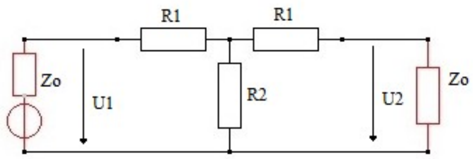
The power attenuation is always twice as large as the voltage attenuation[1]:

$$P_2 / P_1 = (U_2^2 / Z_0) / (U_1^2 / Z_0) = (0{,}7^2 / Z_0) / (1^2 / Z_0) = 0.7^2 = \text{ca. } 0.5$$

$$a_p(dB) = \mathbf{-10} * \log(P_2 / P_1) = \mathbf{-10} * \log(0.5) = \mathbf{3dB}$$

Calculation of resistors





At a given system impedance Zo and a ratio v between input voltage U1 and output voltage U_2

$$v = \frac{U_1}{U_2}$$

the resistances of a symmetrical Pi attenuator are calculated to

$$R_1 = Z_0 \frac{v^2 - 1}{2v}$$

$$R_2 = Z_0 \frac{v+1}{v-1}$$

The following applies to the T-attenuator:

$$R_1 = Z_0 \frac{v-1}{v+1}$$

$$R_2 = Z_0 \frac{2v}{v^2 - 1}$$

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1 ... of course only under the condition that generator and load resistance are equal ($RG = RL = Z_o$).