

Parallel Circular Conductor Transmission Line Calculator

Serge Y. Stroobandt, ON4AA

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Introduction

This calculator is a tool for designing balanced transmission lines with a specific desired characteristic impedance Z_c and made of parallel circular conductors of a given diameter d . Round open wire **Lecher line**, **ladder or window line** and **twin-lead line** are all balanced transmission lines which are frequently encountered as the feed line of severely mismatched multi-band wire antennas, especially the **G5RV antenna**. The conductors being massive or hollow does not affect the characteristic impedance.

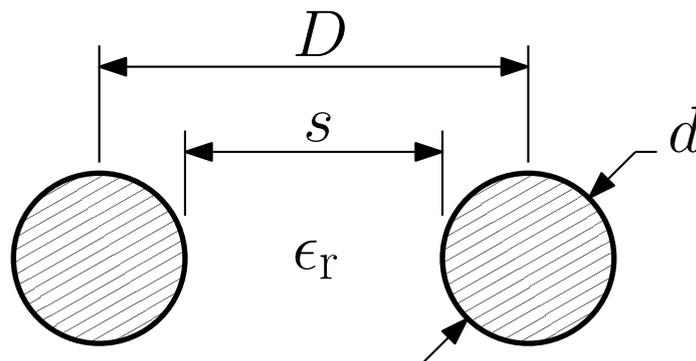


Figure 1: Parallel circular conductor transmission line; dimensions.

Construction

Here is an excellent construction suggestion by **Leon Salden, VK3VGA**. He devised a **ladder line spreader** built from durable and readily available materials; a black cable tie and black polyethylene (PE) **irrigation extension tube**. For smaller separation distances, **black LED spacers** can also be used.

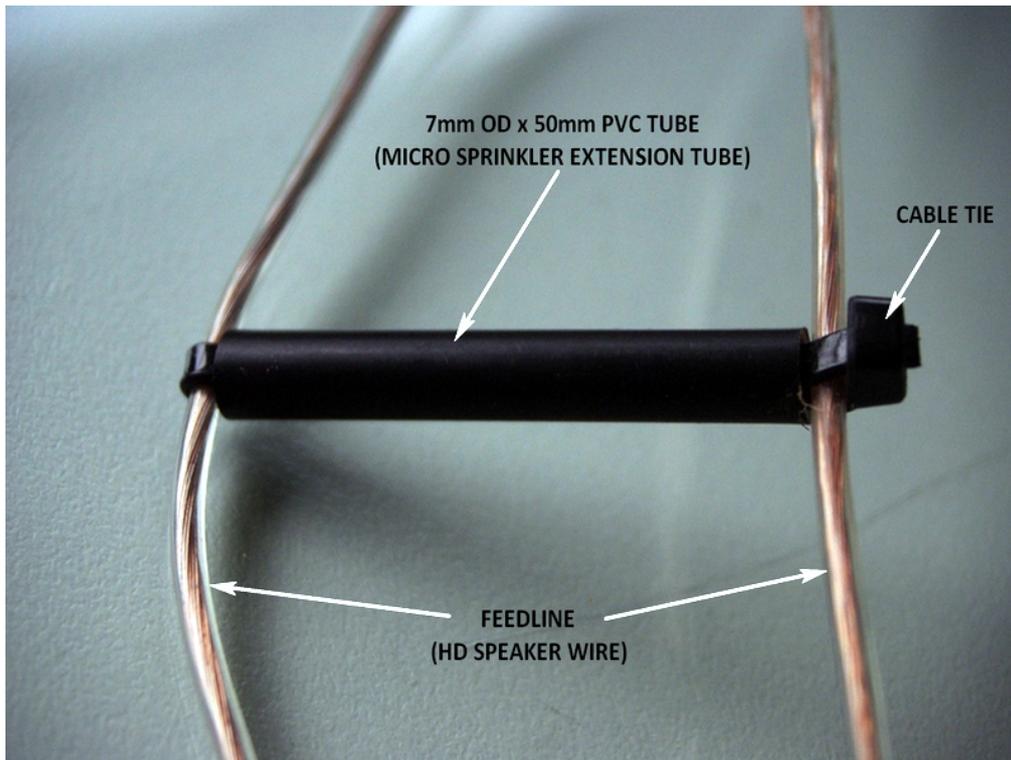


Figure 2: Ladder line spreader built from black irrigation extension tube and a cable tie. *Source: Leon Salden, VK3VGA*

Formulas

Following formula can be derived for **the characteristic impedance of a parallel wire transmission line:**¹

$$Z_c = \frac{Z_0}{\pi\sqrt{\epsilon_r}} \operatorname{acosh}\left(\frac{D}{d}\right) \quad (1)$$

The **characteristic impedance of free space** is exactly:

$$Z_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} = \mu_0 \cdot c_0 \approx 376.73 \Omega \quad (2)$$

where:

$c_0 = 299\,792\,458 \frac{\text{m}}{\text{s}}$: the speed of light in free space

$\mu_0 = 4\pi \cdot 10^{-7} \frac{\text{H}}{\text{m}}$: the free space permeability

$\epsilon_0 = \frac{1}{\mu_0 c_0^2}$: the absolute permittivity of free space

Z_0 : the characteristic impedance of free space

Rearranging and solving Eq. 1 for D :

$$D = d \cdot \cosh\left(\pi \frac{Z_c}{Z_0} \sqrt{\epsilon_r}\right) \quad (3)$$

$$s = D - d \quad (4)$$

where:

D : the centre to centre distance

d : the diameter of the circular conductors

Z_c : the desired characteristic impedance of the transmission line

Z_0 : the characteristic impedance of free space

ϵ_r : the relative dielectric constant of the surrounding medium (1.00054 for air)

s : the space between the circular conductors

Brython source code

Here is the **Brython** code of this calculator. Brython code is not intended for running stand alone, even though it looks almost identical to **Python 3**. Brython code runs on the client side in the browser, where it is transcoded to secure **Javascript**.

License: **GNU GPL version 3**

Download: [zc.circular.py](#)

Measuring characteristic impedance

The characteristic impedance of a transmission line can easily be determined from two vector network analyser (VNA) measurements. This is explained in detail [here](#).

References

1. Robert A. Chipman. *Theory and Problems of Transmission Lines*. McGraw-Hill Book Company; 1968.



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