Do I need a 50Ω input/output?

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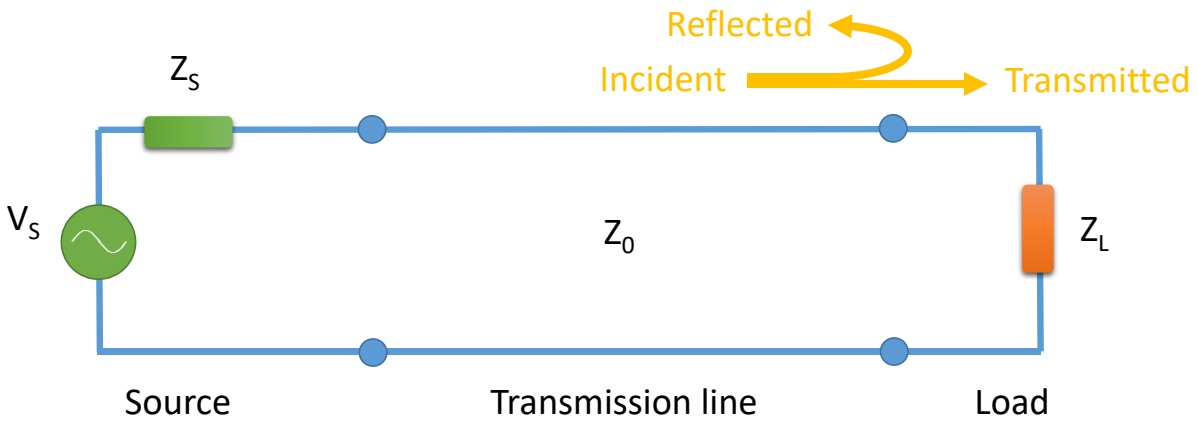
INTRODUCTION:

When searching for an amplifier, one can see that some models present inputs and outputs rated to 50Ω, while some others not. The aim of this note is to clarify the cases in which the use of an amplifier with 50Ω impedances is necessary and the cases where it is not required or even is inadvisable.

WHY 50Ω?

Consider an electrical signal travelling through a very long cable. Due to its finite velocity of propagation, it will take some time in reaching the end of the cable. When this happens, part of the signal is transmitted to the load and other part is reflected in the opposite direction. When the reflected wave reaches the start of the line, a new reflection can occur, and so on. Reflections in transmission lines are undesirable because they cause distortion in the signals. The only way to avoid these reflections is to match the characteristic impedance of the cable to the impedances connected to each side, i.e. $Z_L = Z_0 = Z_s$ in the figure below.



The characteristic impedance Z_0 of the cable can be interpreted as the impedance that a signal would see when the length of this cable is infinite. The most common value for Z_0 in coaxial cables is 50Ω. Setting $Z_L = Z_0$ and $Z_S = Z_0$ the reflections are eliminated and we say that the load, the source and the line are adapted.

The effect of the reflections depends strongly on the length of the cable and the frequency of the signals crossing through the transmission line. When the length of the transmission line is much higher than the wavelength of the signal (high frequency regime) the line is considered electrically long and impedance adaption must be considered. On the other hand, when the length of the transmission line is much lower than the wavelength, it is considered electrically short. In short lines reflection phenomena occur in a very brief time and therefore impedance adaption can be disregarded.

ADAPTED AMPLIFIERS:

Adapted amplifiers have input and output impedances of 50Ω and are designed to operate with matched lines, sources and loads. They are essential when the frequency is so high that the transmission lines become electrically long. However, its use is associated to some limitations and therefore the user should determine if its application requires this type of amplifiers or not.

Adapted amplifiers require the use of loads with a stable value of 50Ω. This would discard loads such as piezoelectric transducers due to its frequency-dependent and complex impedance. Although adaption networks can be implemented to convert this impedance to 50Ω, its resonant profile, temperature dependence and factory variations between transducers of the same model will make broadband adaption difficult and costly. It is worth to note that standard amplifiers with low output impedance (instead of 50Ω) usually deal with a wide range of load impedances that easily include the specific case of 50Ω loads.

In addition, 50Ω is a relatively high value for the output impedance of an amplifier, especially in power applications. The output impedance of the amplifier and the load results in a voltage divider where only one half of the generated voltage is applied to the load. If high currents are required, the user should consider that the output impedance will produce a 50V drop for each ampere supplied to the load.

SO… DO I NEED AN ADAPTED AMPLIFIER?

Due to the above limitations, we only recommend adapted amplifiers when the cables are long and the frequency so high that their use is inevitable. Non-adapted amplifiers can be employed in any other case provided that the lines are considered electrically short. The determination of whether a transmission line is electrically short depends on its length (L)

relative to the wavelength of the signal (λ). As a rule of thumb for most applications, the maximum length at which a line can be considered electrically short is given by L = λ/10. For example, this limit occurs at 20MHz for a RG-58 coaxial cable with a length of 1m. Below this frequency and unless longer cables are used, impedance adaption can be disregarded.

Please, contact us if you have any question about your specific application and its potential transmission line effects.

ABOUT CIPRIAN

Ciprian offers amplifiers with a low output impedance intended for a general use. They can work either with 50Ω or any other complex load. If anyway you need an input or output with a specific value of impedance, please contact us.

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