3.3 Measurement of the Characteristic Impedance of a Flat Flexible Cable (FFC)

Flat flexible cables are usually used in LCD screens, board-to-board solutions for medical devices, test and measurement equipment, industrial applications, consumer electronics and any other kind of equipment requiring a small, strong and flexible cable for data transmission purposes.

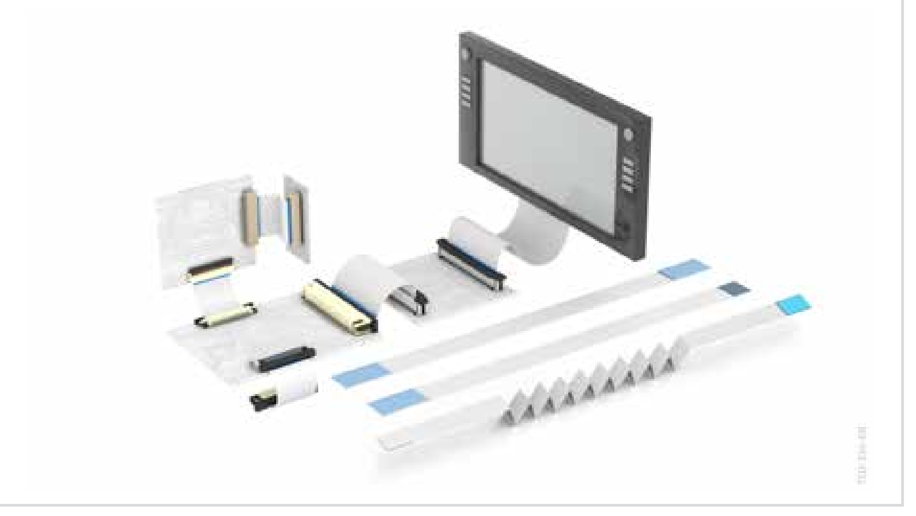

Fig. 1.378: Possible use of ZIF connectors and FFC cables

In order to meet customers' requirements, Würth Elektronik offers 0.5 mm and 1 mm – pitch FFCs – the most common pitches – in various lengths.

Würth Elektronik components used:

- WR-FPC SMT ZIF Horizontal 1.0 mm (686 1xx 144 22)
- WR-FFC Flat Flexible Cable Type 1, 1.0 mm (686 6xx xxx 001)
- WR-FPC SMT ZIF Horizontal 0.5 mm (687 1xx 145 22)
- WR-FFC Flat Flexible Cable Type 1, 0.5 mm (687 6xx xxx 002)

Since it is a compact, thin and light product, it is suitable for low-space applications. Moreover, these cables can be bent without impacting the transmission performance.

Today's technologies require ever higher data rates with efficient transmission. The characteristic (or line) impedance is a key indicator to assess the performance of cables or data lines in terms of data transmission. This fundamental point deserves to be highlighted. The present article therefore summarizes two different methods to measure the impedance: time domain reflectometry and frequency analysis. These two complementary processes enable customers to measure both the characteristic impedance and signal losses through the cable. Most of the time, customers want to know the maximum frequency that can be transmitted by the cable according to a certain losses value.

The study covers FFCs with a 0.5 mm pitch and a 1 mm pitch.

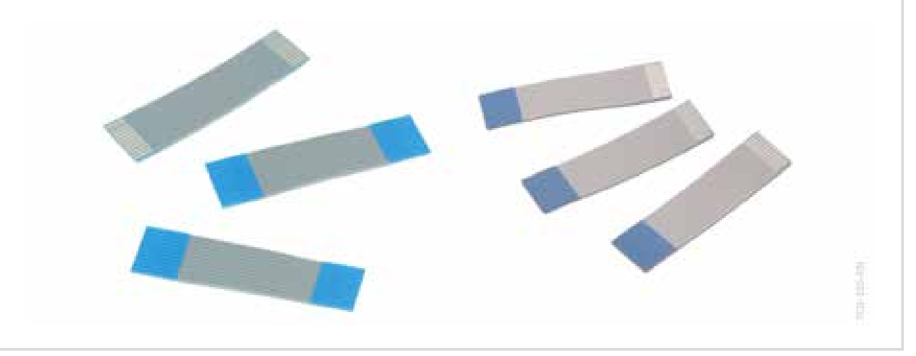

Fig. 1.379: Flat flexible cables

In practice, measurements were carried out by characterizing the cable & FPC couple. It provides realistic test conditions, just like in customers' applications.

Basics on characteristic impedance

The characteristic impedance is an important parameter for signal transmission. If the impedances of a source, a cable and a receiver do not match, a reflection phenomenon will prevent signals from being fully transmitted. Therefore, the cable impedance must be as close as possible to the source and receiver impedances.

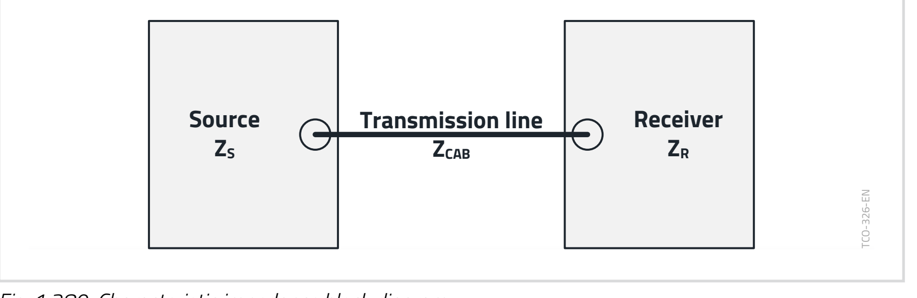

Fig. 1.380: Characteristic impedance block diagram

If a cable is used to provide high power signals and part of it is lost, this may disturb the source and/or the receiver and impact the power efficiency of the whole system. If a cable is used to transmit data, this is less important because signals are usually powerful enough to be decoded at receiver level.

The key indicators to quantify losses are transmission and reflection coefficients. Let's assume that the receiver (Z_R) is adapted to the transmission line. Then, equations are as follows:

$$\text{Reflection coefficient } \rho = \frac{Z_{CAB} - Z_S}{Z_{CAB} + Z_S} \text{ and transmission coefficient } \tau = 1 - \rho \qquad \text{(EQ 25)}$$

The reflection phenomenon is not linear. The table and curves below quantify the part of the signal that is transmitted/reflected according to the cable characteristic impedance (for Z_S = 50 Ω):

ZCAB	40 Ω	50 Ω	60 Ω	75 Ω	100 Ω	120 Ω	150 Ω	200 Ω
	11.1 %	0 %	9.1 %	20 %	33.3 %	41.2 %	50 %	60 %
	88.9 %	100 %	90.9 %	80 %	66.7 %	58.8 %	50 %	40 %

Tab. 1.35: Reflection and transmission coefficients according to the transmission line characteristic impedance (for Z_S = 50 Ω)

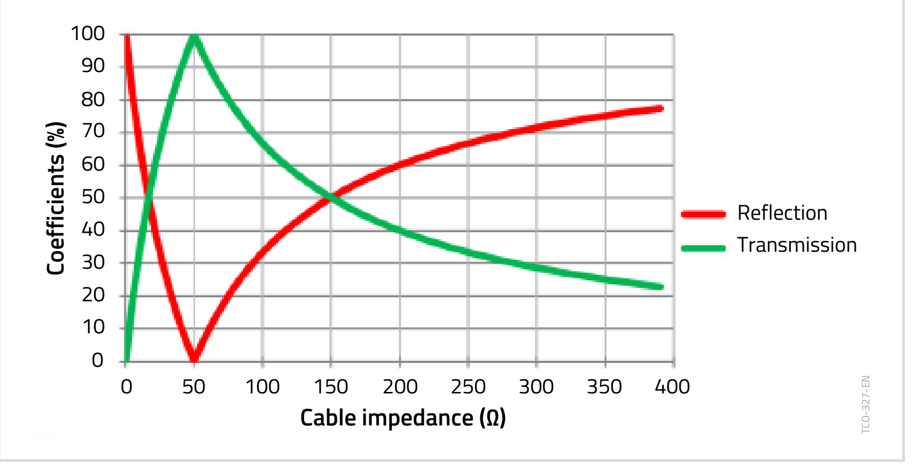

Fig. 1.381: Reflection and transmission coefficients according to the transmission line characteristic impedance (for Z_S = 50 Ω)

According to the previous table and curves, the more the impedances vary, the more important the reflection. This is why impedance matching is important in order to avoid losses during transmission.

It must be noted that the characteristic impedance depends on geometrical parameters of the transmission line as well as on the materials electrical permittivity. Further investigation needs to be conducted to determine the exact physical properties of the materials used and the correct formula to predict the impedance value.

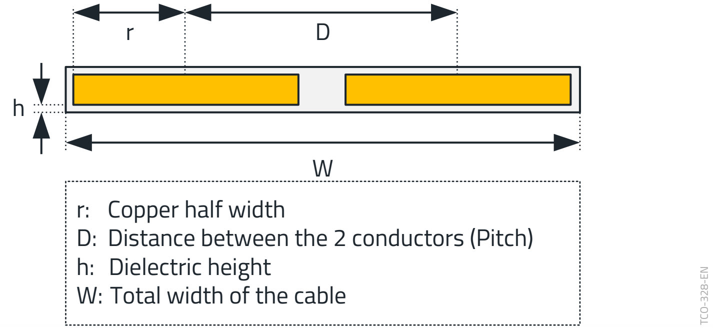

Fig. 1.382: FFC sizing description

According to the literature, the characteristic impedance depends on dimensions (r, D and h) and on the dielectric permittivity ε_R:

$$Z_{CAB} = \frac{276}{\sqrt{\varepsilon_R}} \ln\left(f\{r;D;h\}\right) \qquad \text{(EQ 26)}$$

In order to have a good estimation, the dielectric permittivity and dimensions must be precisely known. Since many different materials are used to manufacture FFC products (blue PET, white PET, glue), it is difficult to assess the dielectric permittivity. This is why measurements are taken to quantify the characteristic impedance.

Measurement methodology

The characteristic impedance measurement can be performed according to two methods:

- Unbalanced measurement (single):
  One conductor transmits the signal and the other one ensures the grounding return (classical assymmetric transmission). Boards have been designed to measure it (as per the following block diagram).

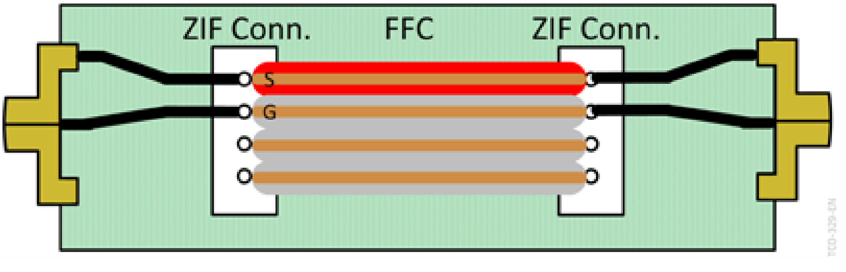

Fig. 1.383: Signal ground measurement board block diagram